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FOREST SERVICE

STAND IMPROVEMENT MEASURES

FOR THE

WESTERN WHITE PINE TYPE

REGION ONE

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In cooperation with

Division of Timber Management, Region One, Forest Service

And other cooperators[1/]

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CONTENTS

INTRODUCTION

The purpose of this manual is to present to Forest officers and private timber operators in the western white pine region of northern Idaho and contiguous portions of Montana and Washington information on objectives and methods of stand improvement as developed and applied in the western white pine type.1/ It is generally recognized that to secure and maintain second-growth stands of desirable composition, which are necessary to produce the high values possible on the better sites, cultural measures are usually required. The need for this class of work is becoming more and more apparent as the acreage of cut-over stands is steadily increased by logging. The heavy investment necessary to protect western white pine forests from fire and disease makes it especially important that they be maintained at full productivity.

Stand improvement in this manual is divided into measures applicable to immature stands, and measures applicable to mature stands. In the first class the objective is mainly to increase the proportion and the quality of the most valuable species. Methods discussed are cleaning, thinning, liberation cutting, and pruning. In mature stands the essential purpose is to remove unmerchantable and usually defective timber to permit the establishment and successful development of desirable reproduction, either by partial disposal by pile and burn methods or by complete disposal necessitating clear cutting and broadcast burning usually followed by planting. In both immature and mature stands, trees removed through the application of cultural measures are, under existing market conditions, seldom of commercial value. Consequently, stand improvement in the western white pine type necessitates a direct investment that can only be realized by enhanced future values. The principles and methods outlined in this manual are generally applicable to the silvicultural problems of the type and should be of assistance in guiding stand improvement work, but in no sense can they take the place of the forester's skill and technic in adapting stand improvement methods to meet the variety and complexity of stand conditions encountered in actual practice.

1/ The western white pine type is defined by the U. S. Forest Service as timber stands containing 15 percent or more western white pine by volume.

WESTERN WHITE PINE TYPE

The commercial range of western white pine (Pinus monticola D. Don) is largely confined to the mountainous portions of northern Idaho, and nearby portions of Montana, Washington, and British Columbia. (Figure 1.)2/ Within this area there is a complex mingling of several forest types of which the western white pine type is of outstanding importance. This type in general occupies the moister creek bottoms and northerly slopes. On account of the rugged topography characteristic of most of the region, the type usually occurs in broken, irregular, "shoestring" bodies and is surrounded and often intricately mixed with other types.

It is estimated that the commercial occurrence of the type is confined to about 2,700,000 acres3/ and it is with this area that stand improvement work is primarily concerned.

The western white pine type is characteristically a mixed forest type ordinarily composed of highly variable associations of six or more species. Stands are normally even aged or at the most, composed of not more than two or three age classes. True all-aged stands are seldom found. In general, stands containing less than 50 percent of western white pine by volume are most common and pure stands are rare. There are, however, many stands throughout the type that contain more than 50 percent western white pine; the most extensive of these stands are found in the St. Joe, Clearwater and Coeur d'Alene River drainages.

The principal associates of western white pine are western larch (Larix occidentalis Nutt.), Douglas fir (Pseudotsuga taxifolia (LaMarck) Britt.), lowland white fir (Abies grandis Lindl.), western red cedar (Thuja plicata D. Don), and western hemlock (Tsuga heterophylla

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2/ Occurrence of the type in British Columbia and as an isolated body in the Flathead River drainage is not shown in this figure.

3/ This is the area of Zone One white pine both within and outside the National Forests. Zone One, as defined by the Forest Service, includes timber of such species, condition, and location that could be logged under conditions such as have prevailed in the past, and assuming a normal and progressive development of transportation facilities.

(Raf.) Sarg.). These species will hereafter be referred to as white pine, larch, Douglas fir, white fir, cedar, and hemlock. In addition to these five species, Engelmann spruce (Picea engelmannii Engelm), alpine fir (Abies lasiocarpa Nutt.), ponderosa pine (Pinus ponderosa Laws.), and lodgepole pine (Pinus contorta Land.) are minor associates of importance in limited localities.

Natural reproduction, normally composed of several of the above species, is usually prompt and abundant in the type. Seedling stands ten years of age with ten thousand seedlings per acre are common. Stands of 30 to 50 thousand seedlings per acre are not unusual and occasionally stands of 50 to 100 thousand seedlings or even more are found. However, the proportion of white pine seedlings in the reproduction stand is usually low. Hence, though the securing of reproduction is usually not difficult, the securing of reproduction stands of desirable composition is an important problem in the type.

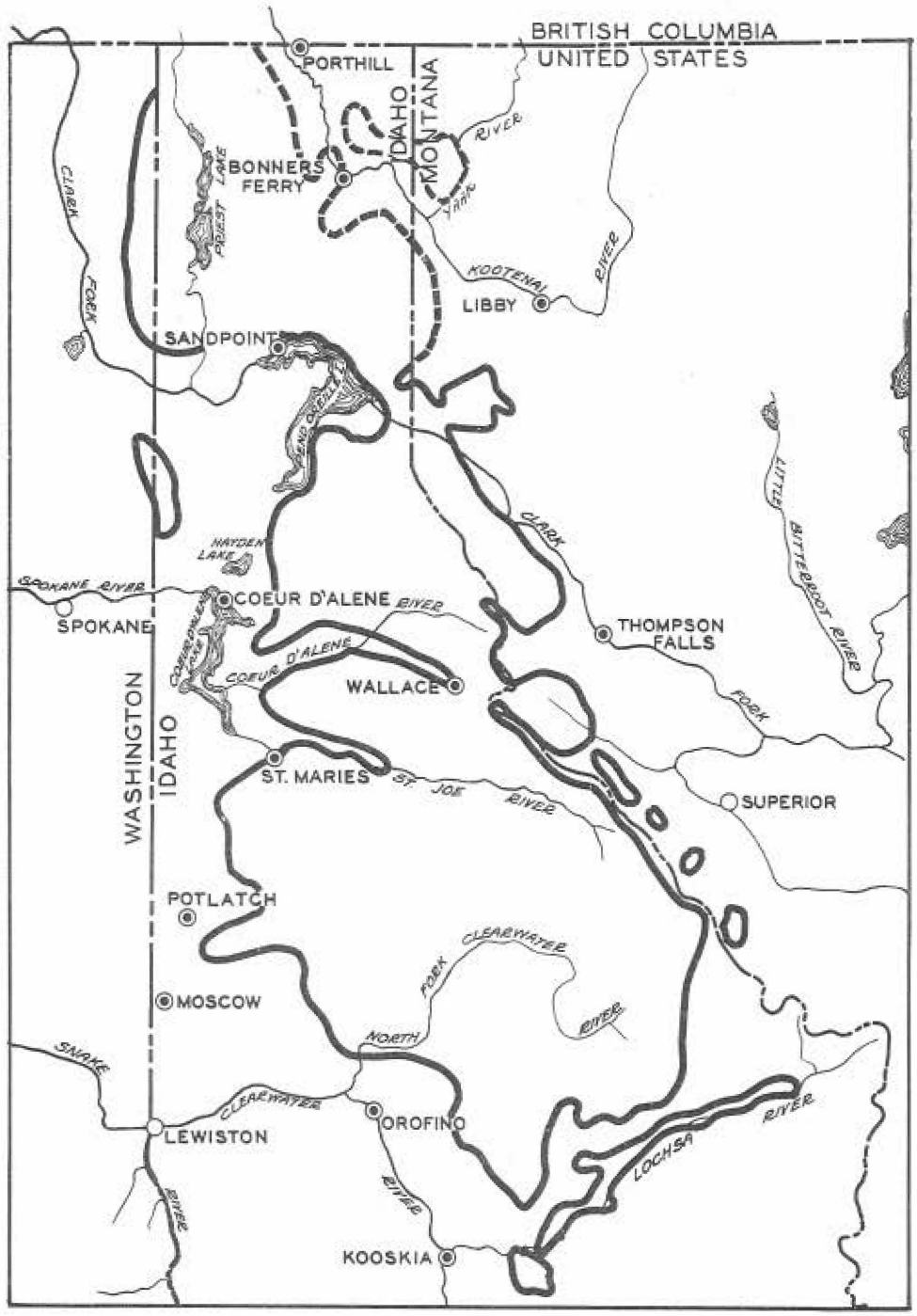

FIGURE I — THE WESTERN WHITE PINE TYPE OF IDAHO, WASHINGTON AND MONTANA

MAJOR MANAGEMENT PROBLEMS

Before a program of stand improvement can be intelligently considered in the western white pine type, several very important and difficult management problems must be clearly recognized.

FIRE

The fire control problem in this type is one of the most difficult and expensive in the United States. The necessity for fire control colors every phase of silvicultural practice in the type, and in some cases unavoidably conflicts with silviculturally desirable methods. For example, the intensity of slash disposal following thinning is almost always a compromise between the advisability of complete disposal to reduce fuel volume to a minimum, the high cost of work, and the fact that slash disposal is of little importance silviculturally. Girdling of undesirable trees, although an economical and silviculturally satisfactory method, has been largely discontinued on account of resultant high fire hazard. Again, needed stand improvement work is not advisable in certain areas until the fire danger has been reduced sufficiently to make the investment in stand improvement reasonably safe. For instance, broadcast burning may be necessary in some single burns, even at the sacrifice of good reproduction already established, to reduce the fuel volume to a reasonable fire risk. One of the major requirements of stand improvement work is that the measures practiced must not seriously increase the fire danger by adding to the fuel volume.

At the same time, properly controlled and directed, fire is a most useful servant to the forester. Burning is the only practical means of physically removing large amounts of inflammable material, which is frequently so necessary to reduce the high fire hazard. Burning also usually brings about soil conditions favorable for the establishment of reproduction, especially white pine. In fact, white pine largely owes its present abundance in the type to past fires. Climax forests of the white pine region contain comparatively little white pine, being composed of more tolerant species, principally cedar, hemlock, and white fir. It seems quite certain that if it were not for fire which breaks up such climax stands that white pine, which often establishes itself promptly after fire, would be largely eliminated. Although the role of fire in silvicultural practice is not the same as its known role in natural succession, there is undoubtedly a close

relation and fire will almost certainly continue to be an important factor in white pine silviculture.

DIFFERENTIAL VALUE OF ASSOCIATED SPECIES

Of the six or more species commonly associated in the western white pine type, only white pine and cedar are of sufficient value to log extensively under existing market conditions. White pine sawlogs and cedar poles for transmission lines, etc., command high prices and their stumpage value compares very favorably with that of the best softwoods in the United States. Of the two species, white pine is of outstanding importance on account of its much larger volume in the type. "Lumbering in the greater part of North Idaho, with the comparatively high logging costs encountered, is made possible only through the high value of the white pine" (10). Cedar, although found throughout the commercial range of white pine, is distinctly local in its distribution, being primarily confined to river flats, benches, and moist north slopes. The highly valued cedar poles form a very small percentage of the total stand in any locality. Much of the existing cedar is overmature and heavily defective, the sound volume usable only for sawlogs and fence posts which bring relatively low prices.

Other species commercially cut in the type, principally Engelmann spruce, larch, Douglas fir, and white fir, seldom have a market value sufficient to carry the high cost of logging and are consequently logged to only a limited extent. More often than not these species, if logged, have a negative value of from a few cents to several dollars per thousand board feet (1). Hemlock, although little cut at present, has promise for future utilization, especially for pulp. It is at present a preferred pulp species by the Inland Paper Company of Spokane. All of these species should be regarded as potentially valuable and under favorable market conditions capable of commanding good prices. When, and to what extent increased demand and technological advances in the use of wood will make profitable utilization of these species possible cannot be stated. White pine, however, will undoubtedly remain the most valuable species.

Based on existing and as nearly as can be anticipated future values, the relative desirability of the principal associated species in the western white pine type are given in table 1. The ranking given in this table should be observed throughout this manual in determining the priority of species in stand

improvement work unless local conditions are such that a different ranking is definitely indicated.

In the management of these mixed stands, composed of species of highly differential value, the forester is continually faced with an expensive and difficult problem of disposing of large amounts of low-value species in order to encourage those of greater value. Hemlock and white fir are the two chief "problem" species; both have a tendency to become badly defective in mature and overmature stands. Hemlock is very abundant throughout the northern and central portions, but practically disappears from the southern portion of the type. White fir is an important constituent throughout the type, but is much more conspicuous in the southern portion where it frequently forms the dominant cover type over considerable areas. Although proper management practice can in the future partially avoid the problem of low-value species through methods of cutting designed to encourage the most valuable species, and through the application of stand improvement measures, the disposal of low-value species is and in all probability will continue to be the major silvicultural problem in the type (11).

Table 1. -- Relative desirability of associated species in the western white pine type in stand improvement work.

Highly desirable. To be favored wherever they occur.	Moderately desirable. To be favored where they do not seriously compete with more desirable species.	Not desirable. To be tolerated only when they do not compete with more desirable species.
Western white pine Western red cedar Ponderosa pine	Engelmann spruce Western larch Douglas fir Lowland white fir	Alpine fir Lodgepole pine Western hemlock

NATURAL ENEMIES

Western white pine has its full share of natural enemies. Chief among these is the white pine blister rust (Cronartium ribicola Fischer) which threatens the very existence of white pine. A heavy investment to eradicate Ribes, alternate hosts to the blister rust organism, is unavoidable, and extensive eradication work has been

undertaken.

Damage to white pine from attacks of the mountain pine beetle (Dendroctonus monticolae) has been extensive in the type. Although the threat from insect attack is not as serious as that from blister rust, it appears that a sizeable investment for insect control must be added to the cost of growing white pine.

Various decay fungi take a heavy toll in the western white pine type, particularly among the so-called inferior species. In fact, the low value of hemlock and white fir is in a large part due to their susceptibility to early decay.

The relation of stand improvement to disease and insects is discussed in another section of this manual.

STAND IMPROVEMENT - GENERAL PRINCIPLES

In immature stands in the western white pine type the primary purpose of stand improvement work is to increase the proportion and the quality of the most valuable species. Stimulation of increment as an aim in itself is a secondary consideration. In mature stands, the main purpose is to remove low-value species to permit the establishment of desirable reproduction either naturally or by planting. In few cases can such work be done primarily to stimulate increment and quality of the reserved stand, unless the material removed has a positive value.

In the selection of stands for treatment and in the determination of the priority and intensity of different classes of work, the aim should always be to secure the greatest total return though not necessarily the greatest immediate return for the money expended. It is preferable to spread the work over as large an acreage as possible, using extensive methods to get the maximum results from a minimum of expenditure rather than to do intensive work on a smaller area with a lower net return per dollar spent. There is practically no limit to amount of stand improvement work that it would be silviculturally desirable to do as there are few stands that could not be benefited by some kind of stand improvement work. There is, however, a definite limit to the amount of money that can justifiably be invested in this class of work. The selection of a particular stand for treatment necessitates a nice weighing of the results to be expected against the cost of the work and a consideration of other areas where money might be more profitably expended.

The manual outlines principles and methods applicable to most classes of work. Each area, however, presents an individual problem. For each project of any size, a written plan should be prepared specifically stating the purpose of the work and the methods to be used.

STAND IMPROVEMENT IN IMMATURE STANDS

DEFINITIONS

The classification of stand improvement measures used in this manual follows, with some modification, terminology formulated in 1917 by a committee of the Society of American Foresters (12). The definitions used here are as follows:

Cleaning: Cutting made in young stands averaging less than two inches in diameter breast high for the purpose of removing undesirable trees or shrubs that are injuring or are likely to injure promising trees. Synonym: weeding.

Improvement cutting: Cutting in a stand averaging more than two inches in diameter, the main object being to remove trees of undesirable form, condition, and species. It is always for the purpose of bringing the stand into better condition and composition for silvicultural management.

Thinning: Cutting made in a dense immature stand for the purpose of increasing the growth rate of the trees that are left and of improving the composition and quality of the stand. As in the mixed stands characteristic of the western white pine type, thinnings and improvement cuttings are usually indistinguishable in actual application; the term "thinning," which is more generally applied, is used in this manual to include both classes of work.

Liberation cutting: Improvement cutting in which desirable understory trees are freed from suppression by removal of undesirable overstory trees which may be either old or advanced growth.

Pruning: Removing nonessential lower limbs from selected crop trees to increase the proportion of clear lumber that may be sawn from the trees.

CLEANINGS

Cleanings offer the greatest promise of large results at minimum expense of any stand improvement measure in immature stands in the western white pine type. Experience and observation to date indicate that the primary object of stand improvement work in immature stands, that of increasing the proportion and quality of the most valuable species, can be most effectively and cheaply accomplished while the stand is very young. As the stand grows older, expense of treatment rapidly increases, and at the same time less can be done to improve composition which becomes more and more fixed with increasing age. To secure improvement in composition of older stands, a heavy sacrifice of growing stock is necessary, a sacrifice that can be largely avoided by early selection of growing stock concentrating growth on the most valuable stems. To be most effective, cleanings should be repeated one or more times.

Stand Selection

There are few stands of reproduction in the western white pine type that do not contain a sufficient stocking of white pine or cedar in need of release from low-value species to make a cleaning very desirable from a silvicultural standpoint. Most naturally restocking burns, timber sale areas eight or more years after cutting, and plantations are in need of cleaning.

Major considerations in the selection of stands for treatment are as follows:

1. Preference should be given to stands that are accessible to main routes of transportation.

2. Preference should be given to stands on the better sites.

3. Stands selected for cleaning should not average more than two inches in diameter. This diameter is approximately the maximum size that can be treated by hand nippers, brush hooks, hatchets, and other light tools characteristic of the quick, cheap methods of treatment possible in small stands. In larger stands, cutting is much heavier, necessitating heavier tools, brush disposal becomes a problem and different methods are required.

4. Stands should be of such age that individual tree differences in growth rate, form, and quality are sufficiently well established to be definitely recognized. In very young stands it is difficult to determine the best seedlings with any degree of certainty and a great deal of needless work will result from cutting out seedlings

that will not develop into competitors of valuable species. Ordinarily, a stand should be not less than seven years old before a cleaning is advisable.

5. Preference should be given to stands in which the proportion of white pine can be materially increased by treatment. A cleaning operation in a stand already largely dominated by white pine is rarely justified, as without treatment the stand will in all probability yield high values at maturity. An exception should be made in the case of stands containing an understory of cedar that could be benefited by the removal of competing and overdense white pine as well as undesirable species.

6. Stands selected for treatment should contain a stocking of white pine or cedar sufficient to indicate that given proper release these species can be expected to form an important part of the final stand. A minimum stocking is about 250 vigorous white pine seedlings per acre. The stand should contain at least 1000 seedlings per acre of all species combined. Cleanings in poorly stocked stands are rarely desirable or necessary unless further reproduction can be expected, as the cleaning is likely to reduce the stocking below that necessary to maintain site protection and to prevent the development of bushy, limby trees.

7. Stands selected for treatment should not contain a fire hazard sufficient to seriously prejudice the safety of the stand. For example, a burn filled with fire-killed trees offers such a fire hazard that an investment in cleaning is a decidedly poor risk.

Tree Selection

The first requisite to intelligent tree selection is an understanding of the relative development of associated species in the type. Information available on the development of white pine in relation to its principal competitors is summarized in table 2. General rules for treatment are also suggested. In competition with less tolerant species, principally larch and lodgepole pine, white pine is, in the open, strongly overtopped during the early years of stand development. However, unless badly crowded, the more tolerant white pine will largely overcome its early growth handicap and will form an important component of the stand at maturity. Under shade, larch and lodgepole pine cannot compete with white pine. In competition with more tolerant species, most importantly hemlock and white fir, exactly the opposite is true. Under shade, white pine will relatively lose ground, while in the open, it will from the first largely dominate these

more tolerant species. All things considered, the development of white pine is relatively the best in the open.

Cedar is a very tolerant, shade-demanding species and characteristically develops as an understory under less tolerant species. It grows well under white pine and wherever practicable it should be encouraged. Mixed white pine and cedar stands are the highest value combinations that can be grown in the type.

In the selection of trees to be cut and to be left it should be again stressed that the major purpose of this work is to increase the proportion of the most valuable species in the stand by releasing the better trees from excessive competition by low-value species. It is neither necessary nor desirable to attempt to eliminate all but the selected trees and the mechanical cutting of everything but white pine, cedar, and one or two other species must be avoided. In general, areas containing only low-value species should be left untouched. Silvicultural experience and observation indicate that white pine attains its best quality in rather dense mixed stands and this point should not be forgotten in stand improvement work. The relative desirability of species, as shown in table 1, page 7, should not be slavishly observed. For instance, white fir in the southern part of the type is a more desirable species than in the northern part, and this fact must be taken into account in the selection of species. Deciduous brush and trees seldom offer serious competition to established reproduction in the western white pine type. Their presence is usually beneficial as a temporary ground cover under which coniferous reproduction develops readily. Where deciduous species do cause important competition, they should be cut the same as coniferous species.

Methods and Tools

It has been found impractical to mark each tree to be cut or reserved. A better procedure is to train the cutting crew to select the right trees to cut and to leave. Although the training required for unskilled labor is considerable, the time is well spent. At the beginning of a job it is desirable to demonstrate the work on several small sample areas of a tenth to a half acre each and to explain the process thoroughly to the crew. During the progress of the work the cutting policy should be checked currently for consistency and adequacy.

Crew units of not more than ten men to the foreman or qualified strawboss have been found the best. It is difficult adequately to supervise larger crews.

Table 2. Relative development of principal white pine competitors and suggestions for treatment in cleaning.

Species	Stand condition	Relative development and probable final composition of naturally grown stands.	Suggested treatment
Western hemlock	No overhead shade. Easterly and westerly slopes and extensive flats.	Hemlock will normally be outgrown by white pine, which at maturity will form the bulk of the dominant stand with hemlock largely as an understory.	Remove all hemlock as large or larger than the white pine for a distance of 4 to 6 feet from the better white pine seedlings and remove all advance growth hemlock wherever found. If a good stocking of cedar is present, partially thin out the hemlock to favor cedar as an understory in place of hemlock. If white pine is clearly outstripping the hemlock no treatment is necessary except as may be necessary to favor cedar.
Western hemlock	Under shade and on most north slopes.	White pine will barely hold its own; or under heavy shade will be outgrown by the more tolerant hemlock. Without cultural treatment, hemlock will form an important part of the dominant stand definitely crowding out white pine.	Remove all hemlock more than two-thirds as high as the white pine for a distance of 4 to 6 feet from the better white pine seedlings, and in very dense stands remove hemlock of all sizes for a distance of about 2 feet from the white pine to give root release. If cedar is present, cut hemlock for a distance of about 2 feet around the better cedar seedlings. Most of overwood should be removed.
White fir	Any stand in which white fir is found.	White fir will at least equal white pine growth except under conditions very favorable for white pine. Without cultural treatment, white fir will form an important component of the dominant stand.	Remove all white fir more than two-thirds as high as the white pine for a distance of 6 to 8 feet from the better white pine seedlings.
Western larch	No overhead shade. On east, west, or south slopes. Larch seldom of importance under shade or on north slopes.	Larch will strongly overtop pine during the early years of development and best information indicates that a certain percentage will maintain its height advantage throughout the life of the stand. White pine grows well, however, with larch and unless badly crowded will grow up through the larch and form a good proportion of the final stand. The extremely rapid early height growth of larch often produces an impression of dominance over the pine that is more apparent than real except on sites very favorable for larch development.	Remove all larch as tall or taller than the white pine for a distance of about 8 feet from the better white pine seedlings. Larch no taller than the pine at the time the cleaning is made will seldom interfere with the development of the pine.
Lodgepole	No overhead shade. On east, west, and south slopes or extensive flats. Lodgepole seldom of importance under shade or on north slopes.	Lodgepole makes exceptionally vigorous and rapid growth in early life, usually developing into undesirable "wolf" trees in young white pine stands. White pine will, however, eventually outgrow the lodgepole, although in early life it is held back, and to some extent killed, by any large amount of lodgepole reproduction.	Remove all lodgepole more than two-thirds as high as the white pine for a distance of 6 to 8 feet from the better white pine seedlings. An important exception is in case of severe sites, particularly south slopes and extensive flats where lodgepole should be cut only where it is very dense or is seriously overtopping the white pine. On such sites the site protection value of the temporary lodgepole is important and it is unwise to open up the stand more than is absolutely essential.
Douglas fir	Any stand in which Douglas fir is found.	Douglas fir will about hold even with white pine during the early part of the life of the stand, and its vigorous, rather bushy growth makes it a serious competitor of white pine where it occurs. It seldom, however, is present in large numbers on good white pine sites.	Remove Douglas fir as tall or taller than the white pine for a distance of 6 to 8 feet from the better white pine seedlings. As in the case of lodgepole, an exception to this rule should be made in the case of severe sites where less cutting should be done to maintain site protection.

It is usually desirable to break up the area to be treated into small units. Sometimes natural boundaries such as creeks, ridges, gulches, etc., can be used. A system that has been found to be very satisfactory, particularly in dense stands, is to divide the area up into strips from a half chain to a chain in width by means of string lines. Each man is then assigned to a strip. Advantages are: (a) Each man is responsible for a definite area and the foreman can readily check his work; (b) the area is covered systematically and completely.

Trees less than two inches can best be cut by means of hand shears of the type of the No. 3 "Forester's" tool.4/ Tests have consistently shown that the output can be about doubled by using the shears as compared to the axe. The tool will not become easily dulled or damaged and is safer to use than edged tools, especially with unskilled labor. A three to four-pound Collins brushhook has been found very effective in Region Five (California) (14), though it has been little used in the western white pine type for this class of work. The "Little Giant" tool, a combination brushhook and axe developed in Region One, has considerable promise of being an effective tool for this work. It has been found highly productive in right-of-way clearing and should be useful in stand improvement work. An advantage of the brushhook type of tool is that these tools can be used to cut trees up to five or six inches, making unnecessary the carrying of an axe to cut trees over two inches which is the maximum size for hand shears. A hatchet is an effective and safe tool only in the hands of a skilled man and is not recommended for general use on CCC or similar jobs. Cleavers, machetes, bolo knives, and sundry other types of edged hand tools, though used successfully in other Regions, particularly in hardwoods, probably have little application in the western white pine type. A 3½-pound double-bitted axe is recommended for trees over two inches.

When shears are used, the shear crew should go through the stand first and cut everything less than two inches to be cut. The shear crew should then be followed by an axe crew cutting the larger trees.

Ordinarily, trees should be cut within 18 inches of the ground. The exact height is immaterial; the essential object is to cut low enough to effectively remove competition. Topping is sometimes permissible, although not recommended as little is gained by the practice and it leaves an unsightly area. Cutting a tree close to the ground so that it will die quickly is requisite only when the tree is very close to a reserved tree and prompt

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4/ Manufactured by the H. K. Porter Company, Everett, Mass.

removal of all competition is essential.

If overwood trees are removed in conjunction with the cleaning job, it is preferable though not necessary that they be cut before the cleaning operation is begun. Methods of removing overwood trees are discussed under "Liberation Cuttings."

No slash disposal is necessary for this class of work except in strips approximately a half chain wide along roads and trails that are designated as firebreaks. The slash is light and does not constitute a serious fire menace at any time. In about two years after cutting most of the fire danger is over.

Examples and Costs

Table 3 summarizes important information from most of the cleaning projects that have been undertaken in western white pine. The acreage covered has been small and the work has been largely experimental. Except for the Big Creek job, all trees less than two inches in diameter were cut with the No. 3 "Forester" shears. Larger trees were cut with the axe. No slash disposal work was done except along the road in the Big Creek project. The work was done with CCC boys who were trained to select the trees to cut and to leave. In all cases the primary purpose was to increase the effective proportion of white pine in the stand. Trees of other species were cut wherever they interfered or were likely to interfere with good white pine. Species other than white pine, in the same order of priority given in table 1, were favored where not competing with white pine. The general rule followed was not to cut a tree unless its removal would benefit a tree of desirable species.

The large increase in the proportion of white pine to other species effected by the cleaning is very striking. For all projects combined, the average stand was 32 percent white pine before treatment and 85 percent after treatment. The proportion is even more favorable to white pine than is shown as the percentages are based in each case on the total stand and the after treatment figures include a large number of suppressed and noncompeting seedlings few of which are in a dominant position. Exactly what these percentages mean in terms of stand composition at maturity cannot be said. It seems certain, however, that the cleaning has permanently and very materially increased the proportion of white pine in the stand.

The investment (as measured in six-hour CCC man days) is reasonably low, ranging in all but the Big Creek project from one to five man days per acre. Except at

Table 3. Representative cleaning projects - western white pine type.

Name and location of area.	Stand description	Date work was done	Area covered	Age of stand	Stand composition: Before treatment 1/ Seedlings per acre	White pine	Other species	After treatment 1/ Seedlings per acre 2/	White pine	Other species	Man days per acre 3/
			acres	years	number	percent	percent	number	percent	percent	
Lower Sands Creek. Plots 32 and 33, Deception Creek Exp. Forest, Coeur d'Alene National Forest.	Reproduction stand of white pine, white fir, and hemlock, largely dominated by white pine. No overhead shade. This was a small job, done primarily to put in sample plots. Ordinarily work would not be done in such a stand as it was dominated by white pine to begin with.	Summer 1934	3	20	4,800 over 0.6 inches d.b.h.	42	58	1,100 over 0.6 inches d.b.h.	95	5	No data
Sands Creek Seed Tree Area. Plots 49, 50, 51, 52, Deception Creek Experimental Forest, Coeur d'Alene National Forest.	Reproduction stand of white pine, white fir, hemlock, and larch, with a large percentage of dominant white fir and hemlock. An overstory of white pine seed trees, providing a light to medium overhead shade, was removed at the time of the cleaning.	Summer 1935	45	16	7,800	15	85	1,400	80	20	4-5
Sands Creek Girdling Area. Plots 42, 43, 44, 45, Deception Creek Experimental Forest, Coeur d'Alene National Forest.	Reproduction stand of white pine, hemlock, and white fir with hemlock and white fir largely dominating. A medium to heavy overwood stand of hemlock and white fir provided rather dense shade. The overwood was removed by felling and girdling at the time of cleaning.	Summer 1934	6	14	18,000	22	78	5,000	80	20	No data
Big Creek, Coeur d'Alene National Forest.	Very thrifty reproduction stand dominated largely by larch which overtopped all species except an occasional lodgepole pine. The age and size of this stand makes the treatment on the borderline between a cleaning and thinning.	Summer 1934	29.7	22	5,000 over 4 ft. in height.	57	43	800 to 1,500 over 4 ft. in height.	98	2	21
Lowe Area. Plots 165, 166, 167, Upper West Branch, Kaniksu National Forest.	Reproduction stand of white pine, larch, white fir, hemlock, and cedar, strongly dominated by western larch. No overhead shade.	Summer 1935	5	8	7,800	10	90	2,800	65	35	4
Dalkena Camp #2. Plot 164, Upper West Branch, Kaniksu National Forest.	Reproduction stand of white pine, hemlock, white fir, larch, and cedar, dominated by larch and white pine. Light overhead shade.	Summer 1935	1	10	2,600	49	51	1,200	91	9	1

1/ Except where noted to the contrary, this figure includes all seedlings over 1 foot in height.

2/ Except for the Big Creek project, approximately 500 to 1,000 seedlings per acre were given release. The balance of this number is composed of suppressed and non-competing seedlings that were ignored.

3/ C.C.C. man-days at 6 hours per day.

Dalkena Camp No. 2, these projects were undertaken in stands denser than the average and in areas selected as particularly in need of cleaning. Over extensive areas the man-day cost should not exceed one to three man days per acre. Using skilled labor, the man-day requirement would be materially less.

THINNING[5/]

Thinning as practiced in the western white pine type is essentially similar to cleanings in character but is applied to older stands than can be treated by the quick and inexpensive methods possible in very young stands. The primary purpose is to release trees of desirable species and form from competition by undesirable species to increase the proportion and quality of the most valuable species and hence augment the total value of the stand at maturity. The secondary purpose is to increase the rate of growth. As stated in the section on Cleanings, the most effective and economical time to accomplish these purposes is when the stand is very young. However, large areas of young growth in the type have passed the cleaning stage and are badly in need of cultural treatment if high values are to be produced. Thinning in such stands should be regarded as a job the need for which could have been largely avoided by properly conducted cleanings.

Kinds of Thinnings

Two general systems of thinnings are applicable to the western white pine type. Before this class of work can be intelligently performed, a clear understanding of the fundamental differences between these two systems is essential.

1. Low thinnings (also termed "thinning from below" or "German" method) are essentially an "anticipation of the natural thinning which goes on in every stand" (2). They may be applied in several degrees of intensity, light thinnings removing only suppressed and dying trees and heavier grades removing intermediate and some codominant trees.

2. Crown thinnings (also termed "thinning from above," "Danish," "French," or "high" method). "Crown thinnings rest upon a fundamentally different conception

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5/ Refer to definition given on page 10.

from low thinnings. In low thinnings the forester keeps ahead of nature, a little way in (light) thinnings, a long way in (heavy) thinnings, but essentially follows nature by removing trees as they fall into the lower crown classes. In crown thinnings, the development of the stand is anticipated a long time and the trees which are chosen for the final stand are selected and favored early in life" (2). Only trees that interfere or are likely to interfere with these selected crop trees are cut; other trees, often termed "neutral" trees, are not cut. Some competition from suppressed or intermediate trees is desirable to develop good clear boles in the crop trees and to protect and maintain the site. Two misunderstandings regarding crown thinnings are common: (1) Crown thinnings do not mean cutting largest and best trees in the stand - the best trees for future growth are reserved; (2) by selecting crop trees it is not meant that an attempt is made to select only the particular trees that will be cut as the final crop. Commonly two or three times as many trees are initially selected and released as it is anticipated will actually form part of the final stand at maturity. By crop trees is meant only the best trees in the stand among which are the trees that will make up the stand at maturity.

Thinning to date in the white pine type has been mostly of the low thinning type in that all suppressed and intermediate trees have been cut. The crown thinning principle has been followed only to the extent that the necessity of favoring the most valuable species, principally white pine, has forced considerable cutting in the dominant crown canopy to release these trees. Aside from undoubtedly improved appearance, there is little to commend close adherence to the low thinning method. Principal disadvantages of the method, particularly as applied in western white pine, are:

1. Excessive cost. The expense of attempting to clean up the dense tangle of understory trees common in young stands is prohibitive.

2. Site exposure. The stand is greatly opened up, especially near the ground, by the needless cutting of a great many understory trees, thus permitting increased air movement through the forest and more rapid drying of the forest floor. It is possible that the effect of site exposure will nullify, or nearly so, the beneficial effect of release from competition.

3. Considerable opening of the stand, particularly if followed by slash burning, is very likely to encourage the germination and establishment of Ribes.

4. Windthrow and snow breakage are often greatly increased by suddenly opening up the stand. Dense stands heavily thinned are especially susceptible to such damage.

5. High fire danger. Unless the slash is more or less completely disposed of, the fire danger from this method is greater than any other method as the volume of slash is the greatest and the stand is more open, permitting rapid drying of fuels and spread of fire once started.

6. Too many trees are usually left in the dominant canopy. It is better to maintain the site with understory trees and concentrate volume growth on fewer and better trees in the dominant stand.

Skillfully applied, crown thinnings can almost entirely overcome these disadvantages. In the United States as well as in Europe the trend is decidedly away from the older and traditional low thinnings and toward the more flexible, economically desireble, and silviculturally sound crown thinnings. Except near roads or in recreational areas where appearance is an important consideration, low thinnings are not recommended.

Stand Selection

Major points to be considered in the selection of stands for treatment are as follows:

1. Preference should be given to stands on the better and more accessible sites. Nowhere else can the high cost of this work be justified except for investigative purposes.

2. Stands selected should be between 20 and 50 years of age. Younger stands usually fall in the cleaning classification. Thinning in older stands is not recommended unless the material removed has a positive value.

It should be emphasized that the older the stand the higher the cost of treatment and the less can be done to improve composition. In stands older than about 50 years, dominance is definitely established and the composition of the dominant stand fairly well fixed. Stand improvement work in older stands should be confined to liberation cuttings to remove undesirable "wolf" trees that are often found in such stands.

3. Preference should be given to mixed stands in which the proportion of white pine, and cedar, if present, can be materially increased by treatment. A mixed white pine and hemlock stand on a good site with north exposure

is a common example. Suppose that without treatment white pine would form 30 percent by volume of the stand at maturity. If by thinning the proportion of white pine is increased to 60 percent, a not unreasonable assumption, it is clear that, if white pine were the only species of commercial value in the stand such as is now largely the case, the value of the stand has been doubled. As high quality mature white pine stands on such sites are frequently worth $200 or more per acre in stumpage, thinnings as viewed in this light have considerable economic possibilities.

4. Stands already largely dominated by white pine should rarely be selected for thinning, as without treatment such stands will yield high values at maturity. While the growth rate can be increased by judicious thinnings, especially if begun at an early age and repeated several times, information available on thinning in white pine, both in northern white pine (Pinus strobus) and western white pine, does not show stimulation of increment to be of major importance. Improvement of composition and quality through thinning is of greater importance. Under existing economic conditions, thinning for increment alone is not recommended. White pine stands seldom seriously stagnate in growth.

Tree Selection

The dominant purpose of tree selection is to select the trees most valuable for future growth in order that the value of the final stand will be a maximum. Hard and fast rules cannot be given to determine particular trees to be reserved and to be cut; much depends on the skill and judgment of the marker in perceiving and solving the many silvicultural problems encountered. The following suggestions are given as a guide.

1. Species. Trees of the most valuable species, approximately in the order given in table 1, should be selected as future crop trees. However, this does not mean that only white pine and one or two other species should invariably be selected as crop trees, mechanically cutting everything else. Consideration must be given to the relative form, vigor, size, and position in the stand of prospective crop trees and an estimate made of the probable effect of these factors on the future development of the stand. For example, dominant and vigorous larch, Douglas fir, or white fir should not be cut to release spindly, badly suppressed white pine, but should be cut to release thrifty codominant or possibly intermediate white pine capable of good growth if freed from competition. Where there is a choice between two trees of approximately the same size and value, the tree of best form and position in the stand should be selected. In

actual practice considerable give and take is necessary, and a reasonable balance must be struck between economic and silvicultural desirability of individual trees.

2. Form and vigor. Trees selected to leave should be straight, well formed, of good crown density, and with a general appearance of vigor as evidenced by a good rate of growth and a healthy color of foliage.

Mechanically caused scars, porcupine damage, and broken tips should not be regarded as serious defects, unless the growth or value of the tree is materially affected, which is not often the case. A vigorous, fast-growing, otherwise desirable tree should seldom be cut on account of such defects.

Great reliance should not be placed on the ability of white pine trees to recover and put on good growth when released from severe competition. Recovery of trees badly weakened by suppression is slow and such trees are very subject to snow breakage and windthrow.

3. Competing trees. No exact rules can be given to determine what constitutes a competing tree that should be cut. Dominant or codominant trees offering or likely to offer substantial root and crown competition to trees selected to leave should, of course, be cut. Intermediate or suppressed trees more than three or four feet from reserved trees should seldom be cut as it is believed they little affect the growth of the reserved tree and their presence is beneficial for site protection and to prune the lower branches of selected trees. As it is doubtful if repeated thinnings will be possible, development of the stand over a long period of years must be envisaged. Low-value trees, not at present competing with reserved trees, should often be cut to avoid competition anticipated in the future.

4. Spacing. Too much attention should not be given to uniformity of spacing which is not an end in itself. If the economic and silvicultural objects of utilizing the site as completely as possible by giving the best trees the most favorable conditions for growth are thoroughly understood and consistently applied, spacing will largely take care of itself. A good thrifty tree should never be cut in favor of a much smaller tree solely because the latter is better spaced.

From 250 trees per acre (average spacing 13 x 13 feet) to not more than 500 trees per acre (average spacing 9 x 9 feet) should be selected as final crop possibilities.

The usual tendency is to select and release too many trees. It must be remembered that relatively few and only the very best trees will ever form a part of the merchantable stand at maturity. Judging from white pine yield tables (5), fully stocked stands 120 years of age will contain not more than about 150 trees per acre of merchantable size. Figure 2, a spacing diagram, will be found useful in solving spacing problems.

Methods

1. Marking. Since it is through marking that tree selection is actually effected, it is essential that it be done, or closely supervised, by qualified personnel. It is usually advisable that marking be done by an experienced man in advance of the cutting crew. Marking should be discontinued only when it is certain that equally good results can be had from crew selection. Either trees to be cut or trees to be left, whichever are the fewer, should be marked. In crown thinnings, fewer trees are cut than left and it has been found best to mark the trees to be cut by blazing with a light axe or hatchet. Unmarked trees are then to be left and consist of selected crop trees and trees that are left as "fillers" or as "trainers" to improve the quality of the crop trees. Trees to be reserved can be marked, if desired, by a scrap of magazine paper attached to the tree by a bill poster tack which can be thrust into the bark with the thumb. An aid to marking is to divide the area into strips or small blocks by means of string lines. This practice systematizes the job and insures that no areas will be skipped.

A good practice is for the marker to pick out first the trees he considers the best crop trees and then one by one determine which, if any, trees should be cut to give proper release. When in doubt whether to cut or leave a tree, it usually should be left.

2. Cutting. A 3½-pound sharp double-bitted axe has been found the most satisfactory tool. Keeping the axe sharp is the first requisite of effective work.

One foreman can handle 15 to 20 men, provided he has help with the marking. One man can easily mark for a 20-man crew.

Axemen should be spaced at least a half chain apart and given a definite lane or block to thin.

On slopes it is best to work uphill.

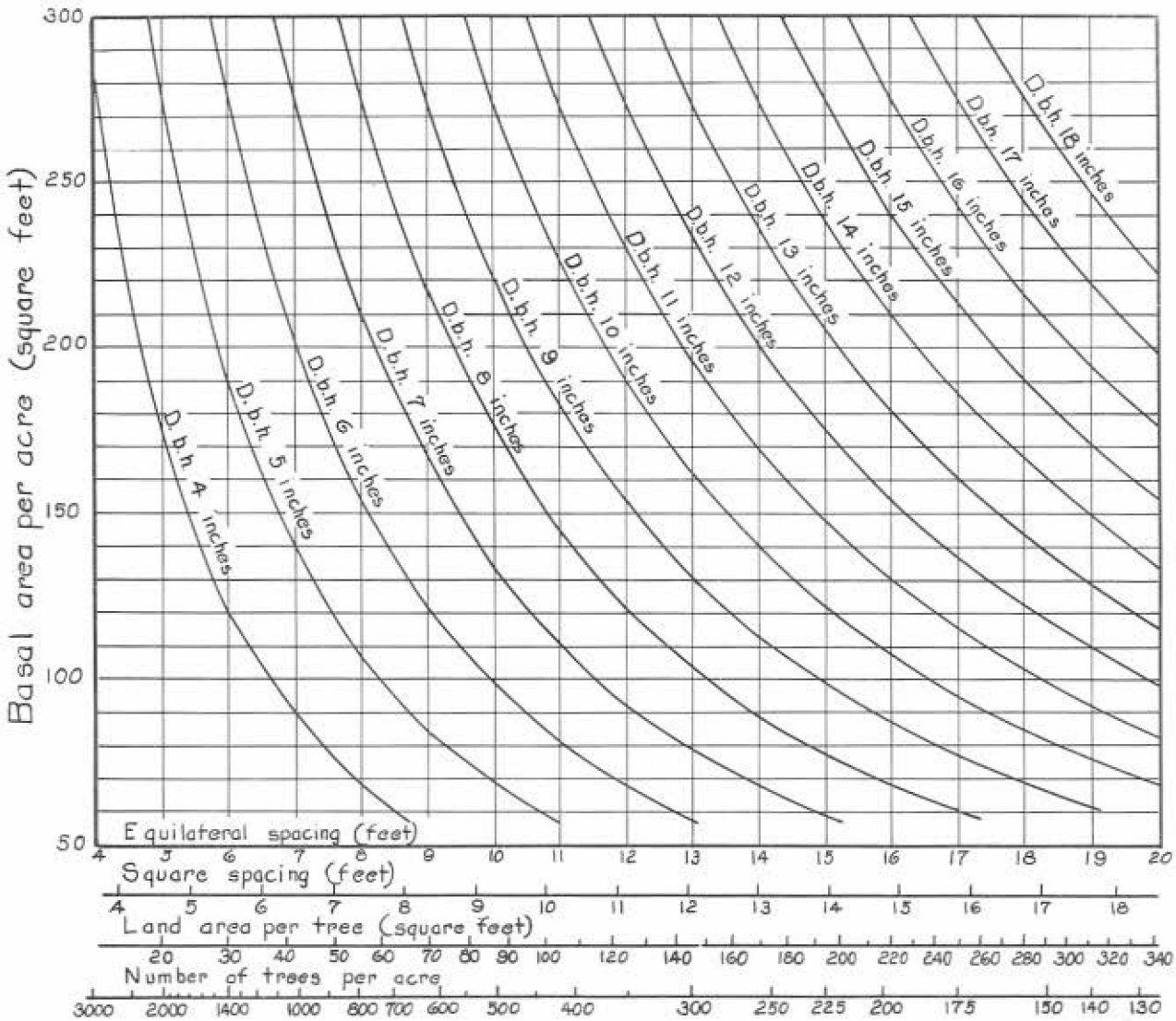

Figure 2.- Spacing diagram

Following thinning it is often advisable to check over the area for trees marked to cut that were missed by the cutting crew and for errors and inconsistencies in marking. A small follow-up crew can sometimes be used to advantage for this work. This after-thinning check is especially important if the trees to be cut and left were crew selected.

"Wolf trees," if felled as a part of the job, should be cut after the thinning as they will then cause somewhat less damage. It is often necessary to have one or more saw crews follow the thinning crew felling undesirable overwood trees. See section on Liberation Cutting.

3. Slash disposal. Except for disposal of slash along roads and in a few special cases, the slash from thinning need not be burned. Trees should usually be left as they fall. Lopping tops and scattering the slash close to the ground reduces the fire hazard to some extent, hastens decomposition, improves appearance, but adds materially to the cost of the job. Lopping should be practiced only when it is particularly important that the fire hazard be kept down or when the improved appearance warrants the additional expense. Where a large area is thinned it may be advisable to dispose of slash in strips 20 feet wide, gridironing the area at intervals of 300 to 400 feet to facilitate quick access to any part of the area and to give an opening to work from in case of fire. Complete slash disposal approximately doubles the cost of the thinning job. Although considerable fire hazard will be created for a few years, it is a risk that must be taken if costs are to be kept within reasonable limits. It should be stressed that crown thinnings create a minimum of fire danger as the volume of slash produced and the opening up of the stand is held to a minimum. Silviculturally, slash disposal is not desirable as slash protects the ground as a mulch and through decay adds to the fertility of the soil.

Slash should be burned for 100 feet on each side of all main highways, 50 feet on secondary highways, and 25 feet on truck trails or wood roads. Disposal should be done where considered necessary in close vicinity to campgrounds or other recreational centers.

The best method of disposal along roads is usually to drag the slash out to the road for burning. In other areas, it is preferable to pile the slash in openings among the trees and burn in the fall. If there is insufficient room to pile all the slash so that it can be burned without scorching trees, it is necessary to progressively pile and burn in the fall either in small

fires throughout the area or by dragging the slash into selected openings, either natural or artificial, where large fires can be built. Progressive burning, while otherwise as efficient as any other method, has the serious disadvantage in the western white pine type that the burning season in the fall is short and uncertain. An important advantage of piling in the summer and burning in the fall is that a large volume of piled slash can be burned in a very short time when weather conditions are favorable.

Examples and Costs

Thinning in western white pine has been mostly of the low thinning type and confined to a few small experimental projects. Information on a number of these projects is summarized in table 4.

The method followed on all of the projects classed as low thinning was to select and mark the best trees. All other trees were cut and the bulk of the slash burned.

In the two Priest River projects and in the Coffee Creek project the primary objective was to create conditions favoring best volume growth and white pine was not strongly favored over other species. As shown by the composition of the dominant stand (dominant and codominant crown classes) before and after thinning, the proportion of white pine to other species was but little increased by the thinning. In the Fourth of July Canyon, and to a lesser degree in the Sands Creek and Cedar Creek projects, white pine was more strongly favored over other species, resulting in a higher proportion of white pine to other species. It should be noted, however, that except in the case of the Fourth of July Canyon job, the stands were above the age limit recommended for thinning. In these older stands composition is fairly well fixed and cannot be greatly altered.

The man-day and cost figures available for these projects are fragmentary and only roughly comparative. The cost of all these projects has been excessive, from about $75 to as much as $134 per acre, depending on density and size of the stand, slash disposal policy, topographical difficulties, and quality of labor employed. The cost of this work has been such as to create a well-founded conviction that this type of thinning is not a practical measure over extensive areas.

In 1934 and 1935 two small areas were thinned by the crown thinning method. The best trees for future growth were selected according to the same standards as

Table 4. Representative thinning projects - western white pine type.

Name and location of area	Description of stand and kind of thinning	Date work was done	Area covered	Age of stand
			acres	years
LOW THINNINGS OR THINNING FROM BELOW				
Benton Creek, Priest River Exp. Forest, Idaho. Plots 102 and 103	Very thrifty and well stocked stand of white pine, larch, white fir, Douglas fir, and an understory of cedar. Thinning removed defective trees and trees in the lower crown classes. White pine, larch, and cedar favored in thinning.	1914 1934	4) 13)	55-60
Benton Creek, Priest River Exp. Forest, Idaho. Plots 157, 158, 159, 160	Stand very similar to that described above but with a higher proportion of white pine. Same kind of thinning.	1933	7.2	75
Coffee Creek, Deception Creek Exp. Forest, Idaho. Latin Square Plot 37	Very dense stand on northeast slope. About half white pine. Balance of stand white fir with smaller amounts of hemlock and Douglas fir. Thinning removed practically all suppressed and intermediate trees and some codominant and dominant trees of poor form and condition. White pine not strongly favored over other species except where a choice was possible between trees approximately comparable in size. The larger of the 6 to 10 "wolf" trees per acre present were girdled. Smaller trees felled. Two weights of thinning made, which are averaged in this table.	1934	1.5	45
Upper Sands Creek, Deception Creek Exp. Forest, Idaho. Plots 26, 27, 28, 29, 30	Very dense stand on southeast slope. White pine largely dominated the stand with white fir, Douglas fir, and a little lodgepole pine making up the balance of the stand. Thinning removed all suppressed and intermediate trees and some dominant and codominant trees of poor form and undesirable species. White pine favored over all other species. Scattering overstory of "wolf" trees felled.	1934-1935	16	60-65
Fourth of July Canyon, Coeur d'Alene National Forest, Idaho	Vigorous and very dense stand of white pine and larch with lesser amounts of white fir and Douglas fir. Understory of cedar and hemlock. Stand thinned to favor white pine with larch as second choice. Cedar understory left. All other trees cut in thinning.	1934	12.9	30-35
Cedar Creek, Coeur d'Alene National Forest, Idaho	Dense stand of white pine, larch, white fir, Douglas fir, with understory of hemlock and cedar. Thinned to favor white pine, and to a lesser extent, larch. Except for cedar understory all but selected crop trees were cut in thinning.	1934	34.7	60-65
CROWN THINNINGS OR THINNING FROM ABOVE				
Upper Deception Creek. Deception Creek Exp. Forest, Idaho.	Dense stand on lower north slope consisting mainly of hemlock. Rest of stand white pine and white fir, with a little Douglas fir and alpine fir. Stand largely dominated by hemlock. Thinning heavily favored white pine, releasing trees of this species wherever they appeared capable of becoming final crop trees. Only trees materially competing with selected crop trees cut. Most of suppressed trees and a large share of intermediate trees left uncut.	1935	18	60
Coffee Creek, Deception Creek Exp. Forest, Idaho. Latin Square Plot 37	Same stand as described under "Low thinnings", above. The best trees for future growth, favoring white pine wherever possible, were selected and released from competition, particularly in the crowns. Non-competing trees, including practically all suppressed trees and most of intermediate trees left uncut. Two weights of thinning made, which are averaged here.	1934	1.5	45

1/ Dominant and codominant crown classes.

Table 4. Representative thinning projects - western white pine type.

STAND COMPOSITION									Cost and output data	Slash disposal
Before thinning				After thinning						
Trees per acre	Ave. diameter	Composition of dominant stand 1/ White pine	Other species	Trees per acre	Ave. diameter	Composition of dominant stand 1/ White pine	Other species			
number	inches	percent	percent	number	inches	percent	percent			
1600	4.2	23	77	500	5.8	27	73		No data	Piled and burned.
1100	5.8	75	25	430	7.8	78	22		No data	Piled and burned.
5800	2.4	45	55	615	4.3	49	51		No data	Slash thoroughly lopped and placed as close to the ground as possible. No burning done.
1700	5.5	65	35	450	7.8	74	26		11 acres thinned with Nira labor at 50 & 60 cents per hour. Approx. 28 man days. Total cost about $118 per acre.	Most of slash dragged to road and progressively burned in large piles. Some slash progressively piled and burned in stand. A small amount lopped and left unburned.
2500	3.1	55	45	500	4.4	91	9		9 acres thinned with CCC & 62 man days per acre. 3.9 acres thinned by Nira labor @ $134 per acre.	Slash progressively burned in small piles within the stand, during winter and early spring.
No data	No data	No data	No data	470	6.8	70	30		18.8 man days and $124 per acre thinning only. Nira labor, overhead included.	Slash progressively burned in small piles within the stand.
2248	3.7	20	80	1748 (388 crop trees)	3.1	55	45		35 CCC man days per acre.	Fire lanes constructed 20 to 30 feet wide at intervals of 5 chains gridironing the area and cleared of all slash by piling and burning. On rest of area slash was lopped and scattered as close to the ground as possible.
5800	2.4	45	55	4200 (606 crop trees)	4.0	68	32		No data	Slash thoroughly lopped and placed as close to the ground as possible. No burning done.

employed in low thinning except that white pine was more strongly favored over other species. Only trees actually competing or likely to compete with selected crop trees were cut; nearly all suppressed trees and most intermediate trees were left. The proportion of white pine in the dominant stand was very materially increased by this marking policy and at the same time a minimum number of trees were cut. In the Deception Creek area all slash was piled and burned in strips 20 to 30 feet in width, the strips approximately 350 feet apart gridironing the area. Slash was elsewhere lopped, placed as close to the ground as possible and left. In the Coffee Creek area slash was thoroughly lopped but no burning was done. The crown thinning method was found to be much faster than low thinning because of the fewer number of trees cut, and it is estimated that costs were reduced from one-third to one-half. Considerable further reduction in cost is possible through improvement in cutting methods and the holding of cutting and slash disposal to a minimum. It must be frankly recognized that extensive application of thinning in the western white pine type is contingent on keeping costs down to an absolute minimum and commensurate to the benefits expected.

LIBERATION CUTTINGS

The best development of reproduction in many timber-sale areas and in many partial burns is often seriously retarded by the presence of overstory and advanced growth "wolf trees." Such trees should be removed by a liberation cutting. Except in the case of selected seed trees left after cutting in timber-sale areas, these trees are often defective, poorly formed, and entirely unmerchantable. A liberation cutting is frequently necessary to secure the full benefit of cleaning or thinning and can often be best made in conjunction with these operations. For instance, there is little to be gained by cleaning or thinning reproduction under an overdense residual stand, unless enough of the overstory is removed to permit reproduction to develop properly.

In practically all instances where reproduction, including a good proportion of white pine, has become established under a residual overstory, white pine will be more benefited than hemlock or white fir, its chief competitors under shade, by partial or complete removal of the residual overstory. Larch and lodgepole are seldom competitors of importance in stands where the density of overstory is a problem. Studies indicate that except on very severe sites development of white pine, once well

established, is best in the open. On the other hand, germination and early survival is favored by a considerable amount of shade. It has been found that favorable conditions for initial survival are created by a forest canopy permitting as little as one-fifth of the total radiation to reach the ground surface (6). It must be clearly distinguished that while a relatively large amount of shade favors early establishment, little if any shade is needed for best development, particularly of white pine, once the stand is well established. A liberation cutting is often required to remove part or all of the residual overstory as soon as the new stand is well established.

Tree Selection

Hemlock is particularly undesirable as a residual tree. It is almost always defective, usually has a large and dense crown, and often occurs as an understory and as an overstory tree in the original stand. After the stand is opened up by fire or by cutting, hemlock, particularly in the understory, has a characteristic tendency to bush out in the crown and form very "wolfish" trees, casting dense shade and seriously retarding the development of surrounding reproduction. "Wolf" trees of this species should ordinarily be cut wherever they are found competing with desirable reproduction. Defective white fir, lodgepole, and old growth cedar are also undesirable, and should be cut wherever they are found overtopping desirable reproduction. Sound trees, particularly white pine, spruce, larch, Douglas fir, and white fir, should seldom be cut. Less than about 20 such trees per acre cause little damage to the reproduction. Where there are more than 20 such trees per acre, their volume is considerable and they should not be cut on account of the reproduction, unless they have a positive stumpage value and consequently can be sold. Needless sacrifice of sound wood volume should always be avoided. Snags, while silviculturally not objectionable, constitute a high fire menace and should ordinarily be felled.

Methods

The usual method of disposal of undesirable overstory trees is to fell such trees and lop the slash. Piling and burning the slash is necessary under the following circumstances: (1) Along roads where slash should be disposed of in accordance with the same policy as in thinning; (2) where slash density is such that it cannot be left without causing serious mechenical damage to reproduction; (3) where more than about 20 such trees per acre are cut, creating in the opinion of the supervisory authority an unwarranted fire menace.

Subject to the general policy outlined above, specific slash disposal measures for each individual area

should be decided on the ground after consideration of the fire danger and other factors involved.

Girdling is a cheaper method of disposal but the practice has been largely discontinued on account of the high fire menace from the resulting snags. Silviculturally, however, the method is satisfactory and where there are less than about 15 trees per acre scattered through heavy reproduction, the method should not be objectionable on account of the fire danger. Girdling should not be practiced without the prior approval of the proper supervisory authority.

An axe notch penetrating one and one-half to two inches into the wood completely encircling the tree two to four feet above the ground has been found the most desirable girdling method both in respect to cost and effectiveness.

PRUNING

The sole purpose of forest pruning is to increase the value of the final product. This is accomplished by removing from the lower part of the tree bole dead limbs and live limbs not essential to the growth of the tree to produce a higher proportion of knot-free wood. Practical difficulties limit pruning to the first 16-foot log in the tree. In western white pine stands 100 to 120 years of age, the merchantable age of the future, the first 16-foot log contains from 25 to 35 percent of the total volume of the average tree. Such stands will produce very little high-value select grades of lumber without pruning. It is estimated by diagramming that "sawed around, rather than through and through, so as to get the maximum number of board feet of clear lumber, a log 16 inches in diameter at the small end, with six-inch central knotty core, will saw out at least 75 percent clear boards and not more than 25 percent knotty" (7). Pruning to produce a high proportion of selects from the butt log has considerable economic possibilities in white pine.

The value of a number of rapidly growing, rather widely spaced young stands in the western white pine type, particularly those composed of nearly pure white pine, can be greatly increased by pruning. White pine does not self-prune readily and in rather open stands

the lower branches are very persistent.[6/] Most plantations need pruning, and it is probable that the best application of pruning is in such stands.

As practically no pruning has been done in western white pine, information on pruning practice must be drawn from experience with other species, particularly northern white pine (Pinus strobus) which is very similar to western white pine (7) (3).

Pruning Practice

1. Tree selection. Pruning should be limited to from 150 to 200 of the best white pine crop trees per acre. Trees selected should be straight for at least the first log, sound, well formed, and growing vigorously. Coarse, very limby, rough, or scarred trees should be avoided. Uniformity of spacing is unimportant, quality being the first consideration.

2. Tree size. For best results pruning should be begun when the tree reaches about four inches in diameter at breast height and repeated several times, each pruning progressively removing nonessential branches at a higher distance from the ground until the desired height is reached. By this practice the size of the central cylinder of unpruned knotty wood is held to a minimum.[7/] The limbs cut are small, greatly facilitating the progress of the work and there is little likelihood that pitch pockets or other defects will develop. It is preferable that branches cut be less than one inch in diameter. Quite serious defects frequently result from cutting larger branches. In western white pine, however, practical consideration of expense and the uncertainty that pruning can be repeated dictates that pruning be delayed until the tree has reached such size that the total desired height can be pruned in one and certainly not more than two operations.

3. Height to prune. Pruning should extend at least as high as one merchantable log above the estimated stump height. Ten feet above the stump is a minimum; 16 feet is preferable and standard practice.

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6/ Limbs are not, however, either as large or as persistent on western white pine as on northern white pine (Pinus strobus).

7/ Three to four inches is the smallest diameter practicable to prune. To this diameter must be added approximately one inch in radius for the wood to grow completely over the branch stubs, making six inches the minimum diameter of the central knotty core.

4. Amount of crown to prune. The lower part of the live crown, including up to about 50 percent of the total crown volume, can usually be removed without adversely affecting the growth of the tree. It is believed that the lower branches of a tree which do not receive direct sunlight contribute little to the growth of the tree and may be more of a liability than an asset in that they use more food than they manufacture. Information is not available on the exact physiological effect of removing different proportions of the lower part of the tree crown. A general rule that has been found satisfactory in a stand with a closed crown canopy is to prune "all live branches up to but not including the highest branches which interlace with the crowns of adjoining trees" (7).

5. Methods and tools. Branches must be cut smoothly and flush with the surface without injuring the bark. If the bole of the tree is injured, the branch not cut flush with the surface of the bole, or if the branch stub is splintered in cutting, decay, pitch pockets, discolorations, and other defects are almost certain to result that will nullify, or nearly so, the benefit of pruning.

The pruning saw has been found the most satisfactory tool and its use is recommended. A variety of pruning saws are on the market, the exact type to use depending on the size and species of the trees to be pruned, the height above ground pruning is to be extended, and individual preference. Branches within about seven feet of the ground can be cut with a hand pruning saw. A type of saw often used has a curved blade 14 to 18 inches long, cutting on the draw stroke with six to eight saw points to the inch, and a pistol grip handle. Some prefer a straight-bladed saw with the usual carpenter saw handle. For higher branches, a 14 to 20-inch curved pruning saw, with five to seven saw points to the inch, cutting on the draw stroke and mounted on a long pole, is recommended. The use of a ladder and hand saw to prune high limbs is productive of high quality work and the method is extensively practiced in eastern plantations. Use of a ladder is believed impracticable in western white pine, however, on account of the steep and brushy terrain encountered.

An axe is probably the fastest pruning tool but its use is not recommended as it has been found practically impossible to do a good job with it (7) (3). Several types of hand-operated shears or nippers are on the market and have been used to some extent. The chief difficulty with these tools is getting a smooth cut close enough to the tree bole. They are also clumsy

to handle except from the ground. Several types of tools with a chisel edge have been developed and have proved satisfactory under some conditions.

A club should not be used to knock off dead limbs unless it is certain that splintered branch stubs and injury to the tree bole will not result. It is possible that some of the smaller dead limbs can be safely removed by the judicious use of a club.

STAND IMPROVEMENT IN MATURE STANDS

DISPOSAL OF DEFECTIVE AND UNMERCHANTABLE SPECIES

Stand improvement in mature stands is primarily concerned with the disposal of defective and unmerchantable species to permit the establishment of desirable reproduction. A large proportion of the existing mature stands in the western white pine type are in an unsatisfactory condition from both a silvicultural and economic standpoint. Many stands are overmature and heavily defective; in others, composition is such that under existing markets only a small proportion of the stand is merchantable. It is expected that the need for this class of work is largely transitory; that as present stands are cut over and placed in productive condition, as stand improvement work is regularly done in immature stands to prevent development of low-value stands, and as improved market conditions permit better utilization of all species, the necessity for extensive stand improvement work in mature stands will be largely avoided. For the present, however, foresters in the western white pine type are faced with the difficult, expensive, but necessary job of making productive areas now occupied by defective and low-value mature stands.

PARTIAL DISPOSAL FOLLOWING LOGGING

Effective application of selective cutting in the mixed stands characteristic of the western white pine type usually necessitates special provision for the disposal of defective and unmerchantable species. Except in young, thrifty, and well-stocked stands (which are excluded from this discussion) where adequate stocking may be reserved for future cuts with no immediate need for reproduction, selective cutting must provide for natural regeneration. Utilization practicable under past and existing market conditions usually does not leave the area in satisfactory silvical condition for the successful establishment of reproduction, even though a reservation of seed trees of desirable species is made. The residual stand is either too dense to permit any reproduction, or if not too dense, the preponderance of unmerchantable species, all prolific seeders, is such as to leave little hope that reproduction including a satisfactory proportion of desirable species will become

established. To provide for satisfactory natural regeneration necessary to keep such stands in productive condition, it is necessary to remove a varying proportion of the least valuable trees - particularly those defective - left after logging.

It must be clearly recognized that the disposal of unmerchantable species is an integral part of the method of cutting. Its necessity would be partially obviated by market conditions permitting close utilization of trees of all species. The policy on National Forest timber sales is to sacrifice no more than necessary of sound but unmerchantable timber in the hope that it will become merchantable in the future. The problem is avoided as much as possible by not cutting for the present in stands containing large, sound, but unmerchantable volumes. A statement of management policy and methods of cutting in western white pine in relation to existing and anticipated economic trends is beyond the scope of this manual. It is certain, however, that the disposal of defective and unmerchantable species in partially cut stands is usually a very necessary supplement to logging merchantable timber.

By far the greatest amount of stand improvement accomplished in the western white pine type has been of this type. For lack of a more descriptive and accurate name, it has been variously termed forest sanitation, sale area betterment, "hemlocking," occasionally thinning, and sometimes simply stand improvement. Silviculturally, it is a combination of an improvement and a shelterwood cutting.

Stand Selection

1. Preference should be given to stands on the better and more accessible sites.

2. Partial disposal must be practiced on exposed sites where shelterwood conditions are necessary to protect the site and to secure reproduction.

3. Preference should be given to stands in which a relatively small volume of defective and unmerchantable timber must be removed following logging to create conditions favorable for natural regeneration. A good example is a stand largely dominated by white pine with unmerchantable species, particularly hemlock, occurring principally in the understory.

4. If areas containing relatively large numbers of sound but at present unmerchantable trees are to be logged, three alternative procedures following logging

are usually possible and should be carefully considered before final decision as to treatment is made. (a) Dispose of sufficient defective and low-value trees to create conditions favorable for natural regeneration, the balance of the residual stand, including a reservation of seed trees of merchantable species, to be reserved in the hope that it will become merchantable sometime in the future. (b) Do no stand improvement work at all for the present, anticipating that a portion at least of the residual stand will become merchantable in the near future. Provision for regeneration would be made at the time of the second cut. (c) Remove all merchantable volumes, clear cut the residual stand, broadcast burn, and plant. Selection of method necessitates an estimate of future values in relation to present costs, and decision is not easy. A broad and liberal appraisal of future values should be made and sacrifice of sound trees avoided insofar as possible. If, however, a reasonable future value of the residual stand cannot be anticipated, clear-cutting should be considered as an alternative and probably cheaper regenerative method. Decision as to method must be made in advance of logging so that the marking of merchantable trees can be done accordingly.

Tree Selection

As it is through careful and understanding tree selection that the best silvicultural as well as economic results are attained, it is essential that selection be done or at least directed by thoroughly competent personnel. Individual marking of trees, either those to be cut or to be left, whichever are the fewer, is recommended for best results. Trees to be cut can best be marked by blazing; trees to be left by a scrap of magazine paper attached to the tree by a bill poster tack. Marking should be discontinued only when it is certain that equally satisfactory results can be had from crew selection.

On protected sites such as northerly slopes all defective white fir and hemlock trees should be cut, that is, any tree with a conk or having the appearance of defect. All suppressed hemlock and white fir understory trees should be cut. Very defective cedar should be cut, except that four or five cedars to the acre, if present, should be left for seed. Sound trees of all species should not be cut except as is necessary to open up the area sufficiently to secure reproduction. If sound trees must be cut, remove those of least value. On protected sites, the sparser the residual overstory, the better will be the development of reproduction, particularly of white pine.

On severe sites such as most southerly slopes and many exposed flats some shade is needed for best regeneration. A minimum of 15 to 30 trees per acre, depending on size and species, should be left. If there are not enough sound trees to form sufficient shade, some defective trees should be left. It is impossible to lay down any generally applicable rule to determine how much shade should be left. In general, from a half to about two-thirds of full shade will favor reproduction on severe sites. It must be borne in mind, however, as stated under the section on liberation cuttings, that while a relatively large amount of shade favors early establishment, little if any shade is needed for best development, particularly of white pine, once the stand is well established. Partial or complete removal of the residual overwood after the reproduction stand has become well established is often advisable.

Methods

Standard practice on National Forests is to fell all material to be removed, pile and burn the slash. Girdling of the larger trees, though undoubtedly a cheaper method and silviculturally satisfactory, has been practically abandoned on account of the resulting high fire danger. Girdling should be employed only with the advance approval of the proper supervisory authority.

Two pile and burn methods are commonly practiced:

1. Pile in summer and burn in fall. This is the most common method. Where the total volume of slash resulting from logging and from green material subsequently felled is not great, all slash can be piled best in one operation, the pine slash being placed at the bottom of the pile to facilitate burning and the green slash placed on top. Another procedure particularly recommended where the volume of logging slash is large is to pile logging slash first, later placing slash resulting from the felling of undesirable species on top of the logging slash piles. This practice prevents large amounts of slash from being scattered on the ground at one time. It also avoids felling trees on top of the logging slash. A disadvantage of this method is that felling will knock over and scatter the logging slash piles to some extent. A third alternative, preferred by some and practically necessary where a very large amount of slash must be handled, is to pile and burn the logging slash first, stand improvement work being accomplished as an entirely separate operation. The exact procedure is not subject to rigid rule; much depends on circumstances.

2. Progressive pile and burn in fall. With experienced labor and suitable weather conditions, progressive piling and burning in the fall is a very effective method and as economical as any other. Ordinarily, logging slash should be piled in advance, the slash from the stand improvement work later being placed on the piles and burned as the felling progresses. This method can also be applied when the logging slash has already been burned. In practice, each man is usually assigned to a small area or strip and does his own burning. A serious disadvantage of this method in the western white pine type is that the fall burning season is too short and uncertain to permit use of this method on a large scale. To keep slash disposal work concurrent with logging, it is necessary to pile most slash in advance of burning. A large amount of piled slash can be burned in a very short time when weather conditions are suitable.

Examples and Costs

Several representative examples of partial disposal are summarized in table 5. As shown, the cost of this work, using day labor, exclusive of piling the logging slash, usually ranges from $20 to $30 per acre, depending on the volume of slash handled. A good average figure is $25 per acre.

To arrive at the total investment per acre, the cost of piling logging slash and the value of seed trees of merchantable species reserved must be added to this figure. On the average, logging slash disposal costs from $0.55 to $0.80 per M board feet cut, although in heavily defective stands where a large volume of material must be handled, the cost has run as high as $1.50 per M. The Beardmore area on the Kaniksu National Forest (table 5) well illustrates the high cost of slash piling in defective stands. In such stands it is undoubtedly better to remove all merchantable material, clear cut the remainder, broadcast burn, and plant. The cost of otherwise putting such areas in productive condition is almost prohibitive. Although the value of the merchantable seed trees reserved at the time of logging subsequently may be realized in whole or in part, their value must be regarded as an investment at the time of logging.

Average total investment per acre for partial disposal of defective and unmerchantable species on the Coeur d'Alene National Forest where conditions are generally favorable for this class of work may be summarized as follows:

	Cost in Dollars Per Acre	
	Range	Average
Disposal of defective and unmerchantable species	20-30	25
Piling logging slash	8-18	12
Value of merchantable seed trees reserved	8-15	10
Total . .	36-63	47

If the residual stand can be logged subsequently, the stumpage value of the timber removed can be regarded as liquidating in whole or in part, as the case may be, the initial investment. If no future values can be anticipated, this average investment of $47 per acre must be regarded as the cost of regeneration.

PARTIAL DISPOSAL IN ADVANCE OF LOGGING

Disposal of defective and unmerchantable material in advance of logging has been experimentally tested as an alternative to the usual practice of disposal following logging. Stand conditions favorable to the establishment of reproduction are created before merchantable volumes are removed. When reproduction is satisfactorily established, the residual overwood composed almost entirely of merchantable trees is clear cut. Silviculturally, the method is a combination of an improvement cutting with the first cutting of a two-cut shelterwood system. Partial disposal in advance of logging is subject to the same considerations of tree selection and disposal methods as partial disposal following logging.

As now envisaged, advantages and disadvantages of the method in the western white pine type are as follows:

Advantages

1. The removal of the mature stand and the establishment of a new one is simultaneously accomplished in a minimum time.
2. An adequate seed source from trees of desirable species is assured.

Table 5. Representative projects. Partial disposal of defective and unmerchantable species following logging - western white pine type.

Name and location of area	Date work was done	Area covered	Stand description	Methods	Cost and output data
		acres			
Burnt Cabin Creek, Coeur d'Alene National Forest. (Ohio Match Company sale of 5/18/23.)	1927-1932	1252	Mature but not decadent 120 to 160-year stand dominated by white pine. Logging removed 21,140 feet b.m. white pine per acre and 3,490 feet other species. Unmerchantable species, principally hemlock and white fir present largely as an understory.	All defective hemlock and white fir felled and placed on piled logging slash. Burning done in the fall. All trees cut marked by a forest officer or by experienced men under immediate supervision.	Direct cost $28.52 per acre. This figure does not include piling of logging slash but does include burning. Output about 7 man-days per acre. Twenty percent contract labor. Balance day labor.
Hudlow Creek, Coeur d'Alene National Forest. (Ohio Match Company sale of 4/14/31.)	1932-1935	352	Same general stand as Burnt Cabin Creek area. Logging removed 17,500 feet b.m. of white pine per acre and a small amount of spruce.	Most of logging slash piled and burned before disposal of undesirable species was undertaken. Practically all trees except white pine, Douglas fir, larch, and spruce were cut on north slopes. On south slopes 10 to 25 sound white fir and hemlock trees per acre, in addition to the above species, were left for site protection. Trees were felled during summer and slash piled. Burning done in the fall.	Bulk of work done by CCC labor. Actual cost unknown. Output about 23 man-days per acre.
Barney Creek, Coeur d'Alene National Forest. (Ohio Match Company sale of 4/14/31.)	1932	102	Same general stand as Burnt Cabin Creek area.	Logged in summer of 1932 and brush piled. Disposal of undesirable species done in fall. Hemlock and white fir piled on logging slash piles and progressively burned as felling progressed. Same marking policy as Hudlow Creek.	Direct cost exclusive of logging slash piling $24 per acre. Day labor. Output 6 man-days per acre.
Granite Creek Area No. 1. Kaniksu National Forest.	1927-1928	5	Decadent 200-year old stand principally of white pine and hemlock. Logged for white pine.	Understory below 8 inches in diameter cut, piled, and burned with logging slash. To further open up stand, 49 trees per acre averaging 16 inches in diameter were felled, slash piled and burned in fall. In addition, 10 trees per acre averaging 26 inches in diameter were girdled. All trees removed marked by a forest officer.	Felling contracted at 15 cents per tree or $7.38 per acre. Brush piling and girdling day labor at $23.38 per acre. Total cost $30.76 per acre. No record of burning cost. Cost of logging slash disposal not included.
Granite Creek Area No. 2. Kaniksu National Forest.	1928	39	Same general stand as Granite Creek Area No. 1.	Same methods and marking policy followed as on Granite Creek Area No. 1 but 39.66 trees per acre were cut, averaging 17 inches in diameter.	Felling contracted at 16 cents per tree or $5.97 per acre. Brush piling and girdling day labor at $22.60 per acre. Total cost per acre $28.67, exclusive of logging slash disposal.
Granite Creek Area No. 3. Kaniksu National Forest.	1928	30	Same general stand as Granite Creek Area No. 1.	Same methods and marking policy followed as on Granite Creek Area No. 1 but 38.8 trees per acre were cut, averaging 16 inches in diameter.	Felling contracted at 14 cents per tree or $5.38 per acre. Brush piling and girdling day labor at $14.26 per acre. Total cost per acre $19.64, exclusive of logging slash disposal.
Lamb Creek, Kaniksu National Forest. (Section 19)	1929	5	Mature 160 to 200-year old stand of white pine, hemlock, white fir, cedar, larch, and Douglas fir. 22.7 M feet, b.m. per acre cut logging.	Residual stand opened up by cutting 34 trees per acre over 8 inches in diameter, averaging 16 inches, and 90 trees under 8 inches in diameter. Brush from logging operation disposed of at the same time. Progressive pile and burn method used.	All day labor. Total cost per acre $47.50 including cost of logging slash disposal. This was a special study plot and costs are believed to be representative of this class of work.
Near Thoroughfare, Kaniksu National Forest. (C. W. Beardmore sale of 10/6/23.)		32	Overmature stand of white pine, cedar, and hemlock. Over 200 years old and rather defective.	Felling removed 21 defective trees per acre, averaging 22 inches in diameter. Slash piled on top of logging slash and burned in fall.	Logging slash piling at $1.49 per M cost $35.80 per acre. Trees under about 7 inches in diameter cut and piled with logging slash. Disposal of defective trees $20.13 per acre. Burning $3.67 per acre. Total cost per acre $59.60.

3. Silvicultural experience uniformly indicates that shelterwood conditions are favorable to seedling germination and early survival.

4. No merchantable seed trees need be reserved; all merchantable trees are removed at one time.

5. The method should be particularly effective on severe sites such as south slopes where shelterwood conditions are usually necessary for the successful establishment of reproduction. Probably the best application of the method is on such sites.

Disadvantages

1. The application of the method is limited to stands in which the number of defective and unmerchantable trees in need of removal will leave a shelterwood of the proper density for the establishment of reproduction.

2. Logging costs will be somewhat increased due to: (a) Increased skidding cost on account of interference from material unavoidably left on the ground following the disposal of defective and unmerchantable species; (b) increased cost of logging slash disposal as special effort must be made to avoid damage to reproduction.

3. Some damage to reproduction from logging will inevitably result, although if the area is well stocked, the loss should not be serious.

To sum up, the method has distinct silvicultural advantages and merits serious consideration in stands where applicable.

Cuttings made in advance of logging to improve the quality of the residual stand and not with the definite intention of removing the residual stand as soon as reproduction is established are, under existing economic conditions, seldom to be recommended on account of the high cost and doubtful returns.

COMPLETE DISPOSAL - CLEAR-CUT AND BROADCAST BURN

The only practicable method of restoring to productivity areas supporting large volumes of dead, defective, or totally unmerchantable timber is to remove all merchantable trees, clear cut the remaining stand, and broadcast burn. Following burning, the area usually should be planted; natural regeneration from surrounding timber should be relied upon only under particularly favorable circumstances. Earlier fears that this method was unsafe to apply have been largely dispelled by confidence and experience gained from a large number of broadcast burns that have been successfully accomplished. If the area is properly prepared and burned under the direction of competent personnel when the weather conditions are right, there is little real danger of the fire getting away and causing more than incidental damage.

There are a number of advantages to the method. The fire danger is reduced below that effected by any other disposal method.8/ It is the only means of physically disposing of large quantities of inflammable material. It produces excellent pathological sanitation. The soil is put in good condition for either planting or natural regeneration; soil damage and erosion have not been observed. Conditions are closely simulated that in the past have favored natural white pine regeneration and development. The method produces quick results; the old stand is removed in a minimum time and through planting prompt regeneration to desirable species is reasonably assured. It is cheaper than any alternative method.

Stand and Area Selection

1. Preference should be given to stands on the better quality and more accessible white pine sites.

2. Consideration must be given to the regeneration of the area. Clear-cutting should not be practiced on severe sites; on such sites a shelterwood cutting is usually advisable. If natural regeneration is expected, attention must be given to the location of the area in relation to surrounding seed source. If the surrounding area is logged, desirable seed trees should be reserved in especially favorable positions to seed in the clear-cut

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8/ By no practicable method can all inflammable material be removed. If all fuels up to and including logs and branches four inches in diameter are completely consumed and larger fuels heavily charred, the clean-up effected by the broadcast burn is considered satisfactory. The charred logs remaining constitute an acceptably low fire hazard.

area. On a slope, for instance, an extra number of seed trees might be reserved along the upper edge of the clear-cut area or on the windward side.

3. Preference should be given to stands containing large volumes of defective and totally unmerchantable timber. Such stands are designated as Class C in the white pine marking rules (13). After the present merchantable volume is removed, the residual stand is entirely without value. Such stands are common in the western white pine type and frequently occur on the best sites. There is no alternative method practicable to restore to full productivity areas supporting such stands.

4. Selection of stands containing a relatively large volume of sound but unmerchantable timber is subject to the same considerations of anticipated future value of timber at present unmerchantable in relation to the cost of stand improvement work discussed on pages 35 and 36. Unless a reasonable future value of the residual stand can be anticipated, clear-cutting is advisable, provided the site is otherwise suitable.

5. Careful selection of the actual boundary of the area to be clear cut greatly facilitates fire control and promotes a good clean-up of fuels. The following recommendations and suggestions are made:

a. Make the boundary as regular as possible. Sharp turns, long fingers and deep indentations make fire control difficult and at the same time often cause an irregular burn with resultant poor fuel clean-up. To secure a sufficiently regular boundary it may often be advisable to include small areas in which other disposal methods might be logically applied.

b. Take full advantage of available fire breaks such as roads, streams, ridge tops, clearings, and natural openings.

c. If the clear-cutting is to extend to the top of a timbered ridge, it is usually best to continue cutting just over the top of the ridge. This avoids scorching trees on the top of the ridge and assists in fire control.

d. If only one side of a narrow canyon is to be clear cut, it is advisable to continue cutting 100 to 150 feet up the opposite slope. It is difficult to prevent a hot fire from spreading across a narrow canyon near the bottom.

Preparation for Burning

1. Felling. The aim in felling is to put the trees as close to the ground as possible. Crossing of trees in felling should be avoided. Trees should ordinarily be felled up and down the slope. If the stand felled is scattered or patchy, much can be done by skillful felling to bunch the slash. Some supplemental hand piling and bunching occasionally may be necessary to consolidate scattered fuels sufficiently to insure that all will be consumed. In sparse stands it is frequently practicable to protect live larch trees from burning by felling trees away from them. Some hand clearing out around such trees may be done. Larch trees, particularly big veterans, are astonishingly fire resistant and will survive a relatively severe fire. It is seldom possible to save trees of other species.

2. Lopping and bunching slash. Under average conditions it is advisable to lop at least the high limbs from the felled trees for a distance of about 50 feet in from the edge of the area and bunch the slash along the extreme outer edge. Lopping and bunching slash near the edges facilitates the starting of fires and promotes a good clean-up along the edges where the greatest difficulty in getting a clean burn is experienced. Lopping and occasionally some bunching should also be done in areas of light slash, moist bottoms and the like, where a hot fire is not anticipated, as otherwise a good clean-up will not result. Lopping of a large proportion of the limbs from the felled trees is usually necessary if green timber is felled and burned in a single season as the lopped slash dries out much faster than when the limbs are left on the tree bole. In some areas lopping is advisable as a safety measure; lopped slash, being more compact, will burn satisfactorily in fairly damp weather when fire will not spread outside the clear-cut area.

Lopping is not necessary where the slash is heavy and has dried out thoroughly. Lopping should not be done until felling is completed and the need definitely apparent; much time can be wasted doing unnecessary work.

3. Snag felling. All snags within the clear-cut area down to a height of six feet should be felled. Snags surrounding the area for a distance of 75 to 100 feet should also be felled. Where fire control difficulty is anticipated, snag felling should be continued as much as 200 feet beyond the edge of the clear-cut area. It has been found that snags outside the area constitute

one of the principal hazards of burning. Such snags are easily ignited by flying sparks even when ground fuels are too damp to catch fire from sparks.

4. Firebreak. A firebreak approximately 20 feet wide cleared of all inflammable material should normally be constructed around the clear-cut area except where natural firebreaks are available. This width has been found sufficient. Firefighting experience has amply proved that if a fire will jump a 20-foot firebreak, it will also jump a much wider one, and a few feet more or less makes little difference.

5. Fire trench. Past experience has shown that a fire line dug to mineral soil and completely surrounding the clear-cut area is seldom necessary. Fire trench should be constructed in advance of burning only in areas of heavy duff or rotten wood where the need for a trench is definitely manifest. Elsewhere, it is advisable to wait until the time of burning and build trench when and where the actual need arises.

When to Burn

Determination of the exact time to burn necessitates careful evaluation of weather, fuel, and safety factors. Hard and fast rules cannot be made; much depends on judgment and experience. Individual consideration must be given to each area. Methods developed in Region One to measure fire weather and forest inflammability should be used as a guide (4) (8).

The ideal time to burn is when weather and fuel conditions are such that fire will spread readily and burn hard and clean inside the clear-cut area while at the same time surface fuels outside the area are damp enough to prevent spot fires. These conditions are most nearly realized between 3 and 7 p.m. on a calm, clear day two or three days following the first fall rain of 0.5 inches or more. At such a time, the concentrated fuels in the clear-cut area which have been thoroughly dried out during the summer are still dry except for surface moisture, while at the same time the moisture content of the duff and light fuels outside the area is too high to ignite from scattered sparks. Under these conditions, very hot fires can be handled with almost perfect safety. Burning should not be attempted immediately (i.e., a few hours)preceding an impending storm.

The character and condition of the fuels has a large bearing on the success or failure of burning quite apart from immediate weather conditions. Heavy concentrations of slash will generate sufficient heat to burn when fairly green or when damp on the surface from recent rains.

Strangely enough, the heavier the slash the more safely it can be burned, as burning can be done when fuels are so damp that fire will not spread outside the slash area. Light slash, on the other hand, must be burned when very dry, or fire will not spread and clean up the area satisfactorily. Burning before rather than after the first fall rains is sometimes necessary for this reason. The more compact the slash, the better it will burn. Green timber can be felled in the spring and early summer and successfully burned in the fall, provided a minimum of two months elapses between felling and burning. Felling one year and burning in the fall of the year following insures that the slash will be well dried out but is objectionable because the slashed areas constitute a very serious fire menace during the second summer.

Spring burning is not recommended. Although weather conditions may be satisfactory and the lighter fuels sufficiently dry to promote ready spread of fire, heavy fuels such as logs and the larger limb wood are usually wet and will not burn. Once fire has covered an area and partially consumed the fuels, it is almost impossible to secure a satisfactory clean-up of fuels by means of a second fire except in midsummer when burning is hazardous and cannot be attempted.

Protection difficulties must also be considered. If the area surrounding a clear-cut area offers a high fire menace, it is necessary that weather and fuel conditions be just right if spread of fire outside the clear-cut area is to be avoided and at the same time a satisfactory burn had. If the surrounding fire hazard is low and no difficulties in fire control are anticipated, burning can be done when dry enough to insure a satisfactory burn. Within limits of safety, the drier the better.

Burning Methods

While proper preparation, favorable weather, and suitable fuel conditions contribute greatly to the success and safety of the burn, much depends on skillful direction of the actual burning. Through experience gained over a number of years on many different areas and under various conditions, fairly definite methods have been developed that can be applied to most situations.

1. Center firing. Center firing, largely developed on large flats in the Kaniksu National Forest, has been found very effective and is recommended wherever the method can be applied. The first fires are set in the center of the area and allowed to spread until a large volume of heat is developed. In areas larger than about ten acres a second series of fires is then set around the area 100 to 200 feet in from the outer edge. These fires merge and are

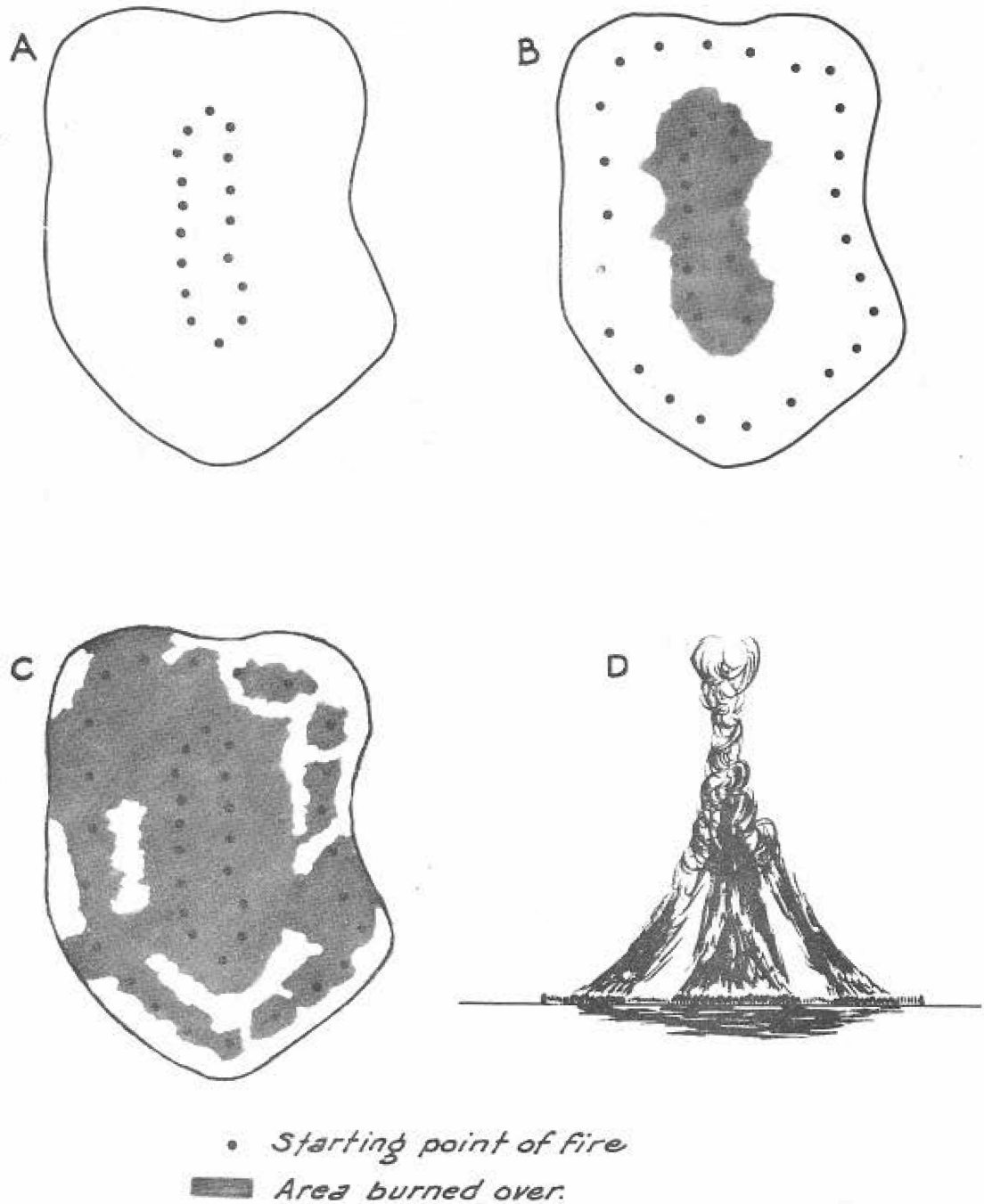

Figure 3.— Diagrammatic illustration of center firing method of burning. A, First fires set in center of area. B, Fires in center united; second series of fires set near edge. C, Inner and outer fire beginning to merge; fire spreading out to edge of area. D, Cross-sectional view of C showing smoke and flame drawn toward center.

drawn toward the hotter fire in the center and slowly back out to the extreme edge of the area. In areas less than ten acres, a second series of fires is usually not needed as the center fire will soon back out to the edges. Some firing along the extreme outer edge may be necessary where outward spread is slow. Steps in the application of the method are diagrammatically illustrated in figure 3. Through center firing, heat, smoke and sparks are drawn toward the center from all sides, making it easy for men to work around the area and at the same time reducing the liability of fire spread outside the area. Contrary to what might be expected, fires set in the center will seldom "run" toward the edge. The large volume of heat developed in the center creates a strong center draft which acts as a stabilizer, preventing rapid outward spread. Wind velocities of from eight to ten miles per hour toward the center frequently have been observed along the edges of areas fired in the center.

The method is most applicable on flats where it is superior to any other. While experience on slopes is limited, it is believed that it can be applied on most slopes up to about 30 percent. On steeper slopes, the natural tendency of fire to spread uphill is likely to be stronger than the center draft developed from a hot fire in the center of the area. A natural aid to center firing on slopes is the draft down the slope that develops in most mountain valleys in the evening. It has been observed that this down draft will sometimes counteract the natural spread of fire uphill. The extent and direction of the natural down draft should be determined in advance of burning, if it is to be relied upon to assist center firing on slopes.

2. Strip firing. On slopes greater than about 30 percent, firing in progressive strips beginning at the top of the area has been found to be most effective. The method is diagrammatically illustrated in figure 4. The first fires are set along the extreme upper edge. As soon as the upper edge is well burned over, another strip or band of fires is set 100 to 200 feet down the slope, which burn up to and join the first strip. This process is successively repeated until the entire slope has been burned over, the last series of fires being set along the lower edge. Strip firing insures that the entire area will be evenly burned over and at the same time avoids a large volume of fire at any one time which is often dangerous and unmanageable on a steep slope.

3. Edge firing. Edge firing consists of setting fires along the outer edge of a clear-cut area and letting them spread toward the center. The method is applicable on small areas of an acre or two or as an auxiliary to strip and center firing on large areas. As an auxiliary method it is chiefly useful to fire small gulches often included in large areas. These gulches should be fired along the edge on both sides, letting the fire back down the slope toward the

bottom. This helps to prevent the whirlwinds that often develop in these gulches and which scatter sparks far and wide. Firing large areas along the edges has not been found satisfactory as fire spread is uncertain and uneven and can easily develop into a dangerous "run" against one side. There is no strong center draft as in the case of center firing, or a strong natural up-slope draft as in the case of strip burning on slopes, to direct fire spread. Smoke and sparks have a tendency to blow outside the area, making fire control difficult.

A combination of center, strip, and edge firing methods can frequently be employed to advantage in a single large area. Each draw, knoll, slope, and change of fuel type presents an individual problem that must be accurately appraised before burning.

Protective Measures

Sufficient man power and equipment should be on hand during burning to promptly meet any fire control need that might be reasonably anticipated. Men should be stationed around the area in accordance with anticipated need, danger points being especially guarded. In addition to usual small tools, which should include a liberal supply of shovels, a number of backpack water pumps should be supplied if water is within reasonable distance. These pumps are very effective in extinguishing spot fires outside the area. Power pumps are valuable to wet down fuels outside the firebreak to prevent sparks from starting fires, to speedily suppress spot fires that may be started, and to cool down an overly hot fire inside the firebreak. Wherever practicable, power pumps should be included as standard equipment for broadcast burning. Brush-burning torches using propane gas are particularly recommended for setting fire. These torches are superior to the Hauck torch burning, a mixture of kerosene and gasoline. Where fires can be started readily, wick torches, consisting essentially of a length of iron pipe filled with kerosene plugged at one end and with a wick on the other, are useful. Matches alone are sometimes sufficient to start fires.

Regeneration Following Burning

Prompt and complete reproduction to the most valuable species following broadcast burning is essential to realize on the rather heavy investment necessary. These requirements can, in most cases, be best met by planting, and white pine should usually be selected as the most valuable species. Ponderosa pine may be selected as an alternative species for planting on more exposed sites, notably extensive flats on the Kaniksu Forest. As broadcast burning is usually practiced on the best sites, successful planting is ordinarily easy. Natural regeneration

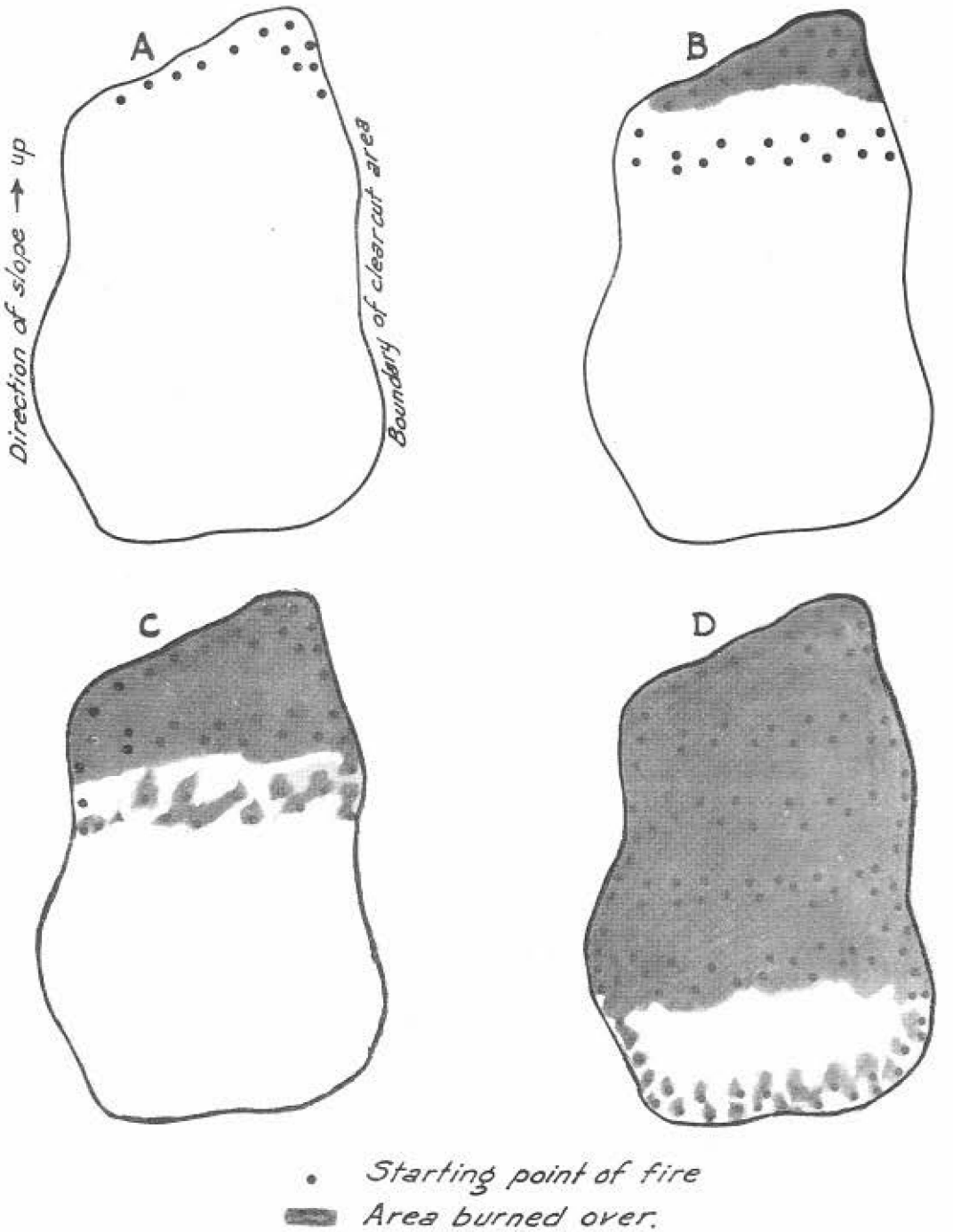

Figure 4.- Diagrammatic illustration of strip firing on slopes. A, First fires set along extreme upper edge. B, As soon as upper edge is well burned out, second strip of fires set 100 to 200 feet down the slope. C, Third strip of fires set. D, Final strip of fires set along lower edge.

should be relied upon only under particularly favorable circumstances.

Planting should ordinarily be done the spring following burning. At this time the soil is in excellent condition for planting and herbaceous vegetation has not yet become established. Some difficulty may be experienced placing the seedling roots in close contact with the soil on account of numerous small roots from the felled stand that have not yet decomposed. This is particularly true of areas from which a heavy stand of green timber was removed the previous year. However, such areas have been planted successfully, and it is not believed that the additional time necessary to plant is sufficient to warrant delaying planting for a year or two until the smaller roots have decayed. Especial care should be taken in planting to take full advantage of the shade and protection afforded by stumps, logs, roots, etc. On most broadcast-burned areas a large quantity of such protection is available. Careful planting followed by a high percentage of survival is, in the end, cheaper than fast, less careful planting resulting in low survival.

Examples and Costs

Prior to 1936 approximately 3,300 acres have been clear-cut and broadcast burned in the western white pine type. Most of this area is in the Kaniksu National Forest. On nearly all areas fire danger was reduced satisfactorily with no undue difficulty in fire control and the ground left in excellent condition for planting. Failure in these respects can be directly attributed to faulty preparation, burning at the wrong time, or poor burning technic, all of which can be remedied. Information on four examples of successful burns is summarized in table 6.

The best concept of suitable weather and fuel conditions under specific circumstances can be had from the Barney Creek and Kalispell Bay areas (table 6) where conditions were considered to be almost ideal at the time of burning.

On the Barney Creek area, which lies on a slope of 55 to 65 percent, a heavy stand of green hemlock and white fir was felled, a part one year and a part two years, before burning. The slash covered the ground to a depth of from three to six feet. Approximately half of the area was burned on September 17 and a half on September 18 by strip- and edge-firing methods. Fire-danger class ratings (4) for six days before burning and precipitation for a month and a half before burning, both as determined at Honeysuckle Ranger Station, located five miles from the area, are given in table 7.

Table 6. Representative projects. Complete disposal of defective and unmerchantable species by clearcut and broadcast burn method - western white pine type.

Name and location of project	Area of project	Description of stand and area	Preparation of area for burning		Burning			Output and cost data
			Felling and lopping of slash	Fire break and fire line construction	Date of burning	Weather and fuel conditions	Burning method and results	
	acres							
Sands Creek Area No. 2. Deception Creek Experimental Forest, Coeur d'Alene National Forest, Idaho.	11.8	Dense stand of 160 to 200-year old hemlock and white fir. All merchantable white pine removed. Approximately 120 square feet basal area per acre. Forty-five to 65 percent side slope.	All standing trees and snags felled up and down the slope as close to ground as possible. All limbs on upper side of felled trees lopped from bole. Slash bunched around edges. Felling completed August 26, 1935.	Fire break 20 to 30 feet in width and fire trench 18" wide constructed around area.	3 P.M. Sept. 17, 1935.	0.63 inches of rain on Sept. 15. Fuels slightly damp at time of burning. Weather clear and calm.	Strip firing. First fires set along extreme upper edge of area. Additional fires set down the slope in progressive strips contouring the slope as area above was burned over. No difficulty in fire control. Fire burned quickly and hard and consumed satisfactory proportion of fuels.	30.6 CCC man-days per acre for entire job, including burning.
Barney Creek, Coeur d'Alene National Forest, Idaho.	170	Dense stand of 200-year and older defective white fir and hemlock. Nearly all merchantable white pine removed. Fifty-five to 65 percent side slope.	All standing snags and all live trees, except a few isolated white pine and larch, felled approximately up and down the slope. No special effort made to fell trees close to ground. No slash lopped. Felling done in fall of 1933 and of 1934.	Fire break 25 to 30 feet in width constructed around area. Eight fire lanes built through area. No fire trench constructed.	7 P.M. Sept. 17, 1935. 6 P.M. Sept. 18, 1935.	0.63 inches of rain Sept. 15. Fuels slightly damp at time of burning. Weather clear and calm.	Strip and edge firing. About half of area burned Sept. 17. First fired along extreme upper edge. As fire did not burn readily next fires set along bottom edge. Lower fires burned hard up slope and caused some fire control difficulty along upper edge. Balance of area burned Sept. 18 by strip method. Fires set in successive strips down the slope beginning at top. Little difficulty in fire control. Fuels drier than on Sept. 17 and fire spread more readily. On both areas consumption of fuels satisfactory. All seed trees reserved killed by the fire.	Felling and fire break construction by day labor at $28 per acre. Burning by CCC labor; no cost records kept.
Watson Mountain Area No. 1. Kaniksu National Forest, Idaho.	160	Dense, overmature, and decadent stand over 200 years old of white pine, hemlock, and cedar. Merchantable white pine all removed. Basal area of stand felled approximately 170 square feet per acre. Area nearly level.	Trees felled parallel to one another. Everything felled but scattering larch and Douglas fir, which were left in hope they would survive the fire. Limbs on upper side of felled trees lopped for distance of 150 feet in from edge of area. Felling begun in August, 1928, and completed July 10, 1929.	20-foot fire break and 16-inch fire trench constructed around area.	9 A.M. Sept. 26, 1929.	0.7 inches of rain fell in 6 days prior to burning. Weather cool and cloudy. Light wind.	Edge firing. Fire set along two sides spreading toward center. Fire spread outside area at several points aggregating about one acre. Consumption of fuels inside area not entirely satisfactory.	Cost per acre. Felling (contract labor) $ 13.40 Lopping slash and building fire break 5.85 Fire trench 0.55 Burning & patrol 0.80 Total $ 20.60
Kalispell Bay area. Kaniksu National Forest, Idaho.	780	Stand consisted of fire killed but standing timber, scattering live larch, and a few small areas of unburned green timber. Originally a dense, overmature and decadent stand of white pine, larch, cedar, and hemlock. Logged over in 1924, mostly for white pine and burned over in 1926. Area on a large flat.	All standing snags and all live timber except larch felled approximately parallel to one another. No slash lopping done except for a little along edges. Felling done in 1934.	Fire break 20 feet wide around part of area. Balance of area bounded by roads or natural fire breaks. Very little fire trench constructed.	3 P.M. October 2, 1935. 5 P.M. October 3, 1935.	Weather clear, calm and dry. Only 0.11 inch rain had fallen in 44-day period before burning. Fuels very dry, containing 11% or less moisture.	Center firing. First fires set in center. As soon as large volume of head was generated, second series of fires set around area 100 to 200 feet in from outer edge. Outer fires merged and were drawn toward the hotter fire in center and at same time slowly backed out to extreme outer edge of fire. Very satisfactory consumption of fuels. Fire burned clean and hard. No trouble in fire control; scarcely a spark escaped outside area.	No data.

Table 7 - Fire-Danger Class Ratings and Precipitation at Honeysuckle Ranger Station, Coeur d'Alene National Forest

Fire-Danger Class Ratings		Precipitation	
Date (1935)	Danger Class	Date (1935)	Precipitation
			Inches
September 12	4	August 4	0.05
" 13	3	" 18	0.75
" 14	3	September 5	0.05
" 15	2	" 15	0.63
" 16	2	" 16	0.08
" 17	2		

Fuel moisture was determined from 16 branchwood samples collected on the area September 18 at the time of burning. Of these samples, which separately included branchwood from one-fourth to two inches in diameter, seven samples were collected from branches on or a few inches above the ground and nine were collected a foot or more above the ground. The 16 samples contained an average of 17-percent moisture content with no significant differences due to size of branchwood or position. This uniformity of moisture content can be largely accounted for by the fact that large fuels absorb relatively less moisture from a rain of short duration but give it up more slowly afterwards than do small fuels. Fuels larger than about two inches in diameter were probably little affected by the rain. At the same time the moisture content of needles, twigs, and fine litter on the ground was 40 percent, well above inflammability which ceases at about 25 percent.

Under these weather and fuel conditions, fire spread readily and burned clean and hard in the heavy fuels of the clear-cut area, while at the same time light fuels outside the area were too damp to be easily set afire. Of the literally millions of sparks scattered outside the area during burning, the only ones that started fires were a few that lodged in standing snags and in rotten logs on the ground. While no fuel-moisture measurements were made on September 17, fuels were obviously wetter than on the 18th, as fire spread much less readily. In the opinion of the men directing the burning work, the 17th was a trifle too wet, while the 18th was just right. The need for accurate estimation of fuel conditions is apparent; at critical times a difference of one day may be decisive.

On the Kalispell Bay area, located on an extensive flat, fuels were composed mainly of timber killed by fire in 1926 and were rather scattered, scarcely covering the ground

in some places and heaped five and six feet deep in others. To get a clean burn throughout the area it was necessary to burn when very dry - which was feasible for the reason that the surrounding area offered a relatively low fire hazard. Burning was done October 2 and 3 before the summer drought had been broken by fall rains. Weather observations, table 8, were made at the Priest River, Idaho, branch of the Northern Rocky Mountain Forest and Range Experiment Station 17 miles from the area. Only 0.11 inches of rain had fallen in a period of 44 days before burning. At the same time, the fire danger (table 8) from a general protection standpoint was relatively low - class 3 for an entire week before burning.

Table 8 - Fire-Danger Class Ratings and Precipitation at Priest River, Idaho, Branch of the Northern Rocky Mountain Forest and Range Experiment Station

Fire-Danger Class Ratings		Precipitation	
Date (1935)	Danger Class	Date (1935)	Precipitation
			Inches
September 27	3	August 4	0.07
" 28	3	" 18	0.51
" 29	3	" 31	0.05
" 30	3	September 15	0.06
October 1	3	" 19	0.09
" 2	3		

The fuels, large and small, were thoroughly dry. Four duff samples taken at the time of burning averaged eight-percent moisture content. Twenty-eight samples of branchwood from 1/8 to 2½ inches in diameter collected at the time of burning on the ground and a foot or more above the ground averaged 10.7-percent moisture content with a total range of only three percent. The moisture content of logs, as measured one to two inches beneath the log surface, was seven percent or less. Burning was done by the center firing method and as would be expected fire spread readily throughout the area and consumed all the fuels except the larger logs. Fire control was very satisfactory; on account of the strong center draft created by the fire in the center, scarcely a spark escaped from the area.

The cost of complete disposal varies almost directly with the volume of timber that must be felled and the burning difficulties encountered. Felling is the principal

expense; slash already on the ground adds nothing to the cost. Costs have in general been higher than necessary for the reason that considerable experimentation in method has been done. On the Barney Creek area, which is representative of areas suitable for complete disposal on the Coeur d'Alene National Forest, the cost of felling and firebreak construction was $28 per acre using day labor. It was estimated, however, that this cost could be reduced about four dollars per acre by omitting the construction of fire lines through the area which were of no value, and by making no attempt to save seed trees. On the Kaniksu National Forest, 957 acres on 12 different areas were felled between 1929 and 1931 at an average cost of $11.51 per acre. The work was done on contract. During the same period and under similar stand conditions, 32 acres were felled by day labor at $22.41 per acre. It is estimated by the Kaniksu National Forest that, on the average, necessary firebreak and fire line construction, burning, and patrol costs from six dollars to eight dollars per acre. The larger the area, the less this cost on an acre basis.

Average costs, using day labor and prevailing wage rates, for complete disposal of defective and unmerchantable species on the Coeur d'Alene and Kaniksu National Forests may be summarized as follows:

	Cost in Dollars Per Acre	
	Range	Average
Felling.....	18-30	22
Firebreak, fire line, burning and patrol.....	6-8	7
Planting.....	9-11	10
Reservation of seed trees...	0	0
Disposal of logging slash...	0	0
Total.....	33-49	39

The total average cost of $39 per acre is roughly comparative to the average cost of $47 per acre for partial disposal. The lower cost of complete disposal is due principally to the fact that no seed trees need be reserved and no additional expense is necessary to dispose of the logging slash. This saving is only partially offset by the cost of planting. Complete disposal, however, is ordinarily practiced in areas where the cost of partial disposal, if attempted, would be considerably more than $47 per acre. The cost differential of $8 per acre is significant only when either method might logically be applied.

COMBINATION OF PARTIAL AND COMPLETE DISPOSAL METHODS

Partial and complete disposal methods may advantageously be combined where logging and silvicultural conditions permit, in a strip- or group-shelterwood method of cutting. A part of the area is clear-cut, either in regular strips or in irregular groups or patches, and the remainder partially cut. The clear-cut areas are broadcast burned. The partially cut or shelterwood areas from which some of the merchantable trees and most of the defective and least valuable trees are removed, supply seed for natural regeneration over the entire area. If cut in strips, the clear-cut strips should ordinarily be from 350 to 400 feet in width and the partially cut strips from 250 to 300 feet in width. The strips may be of any length. Partially cut strips or areas should be located in the most commanding positions available for the dissemination of seed; i.e., on ridges, heads of gulches, etc., and should occupy between 40 and 50 percent of the total area.

A combination of methods, which is capable of many variations and modifications, is particularly applicable in high-value white pine stands containing small volumes of low-value species and where natural regeneration to white pine can be confidently expected. Under these conditions, which are most frequently fulfilled on northerly slopes, such a combination of methods has several advantages:

(1) The total cost of regeneration following cutting is less than if either partial or complete disposal were practiced. Between 50 and 60 percent of the area is clear-cut and separate disposal of logging slash is unnecessary on this portion. The somewhat higher cost of partial disposal on a little less than half the area remaining is more than offset by the fact that no planting is necessary over the entire area.

(2) The cost of logging the residual seed trees is reduced as these trees are concentrated on only a part of the area and because skidding is facilitated by a thorough clean-up of obstructing material in the intervening clear-cut areas. Under these conditions, most of the value of seed trees should be realized.

(3) The entire area is naturally reproduced under conditions very favorable to white pine. Strip and shelterwood cuttings of this type practiced in the past on the better white pine sites have almost invariably reproduced to a satisfactorily high proportion of white pine.

INDIRECT EFFECTS OF STAND IMPROVEMENT

While the direct and immediate effect of stand improvement is on the growth and quality of the stands treated, a number of indirect effects of importance are produced. Effect on white pine blister rust, other forest tree diseases, insect damage and wildlife are here briefly discussed.

EFFECT ON WHITE PINE BLISTER RUST

The effect of stand improvement on the white pine blister rust (Cronartium ribicola Fischer) centers on the effect of the various improvement measures on the establishment and development of Ribes, alternate hosts to the blister rust organism. As the stream type Ribes are not importantly found in areas where stand improvement is practiced, consideration is here limited to the upland Ribes type with Ribes viscosissimum and R. lacustre the principal species.

Factors affecting the germination and establishment of upland Ribes have been studied by the Bureau of Entomology and Plant Quarantine 9/. The following summarizes the more important findings. Germination of Ribes is best on exposed mineral soil. Undisturbed duff surfaces are very poor media for Ribes germination. As a consequence, once a duff surface is established and existing Ribes eradicated, little new germination is to be expected. Considerable shade is a strong deterrent to Ribes; few will survive under a complete forest canopy. Available evidence strongly indicates that Ribes seed remains viable for very long periods of time. Seed is extensively stored in the duff in close proximity to mineral soil. Following a disturbance of the duff cover from logging, fire, windthrow, or other causes, large numbers of Ribes seedlings often appear, and it has been definitely established that seed stored in the duff is the principal seed source. As a consequence, areas that are apparently Ribes-free may after logging or a partial burn become thickly infested with Ribes from seed stored in the duff over a long period of time. Much of this seed was probably produced at some earlier period in the life of the stand when Ribes flourished. Some was undoubtedly introduced by birds and rodents. A severe burn on the other hand destroys all or nearly all stored seed, and establishment of Ribes is then dependent on seed from nearby bushes. If Ribes have been eradicated, such seed source will be eliminated and little new germination can be expected.

These facts of Ribes ecology indicate a close relation between stand improvement measures and Ribes eradication and suggest means by which at least partial control may be effected. A complete forest cover should be maintained insofar as practicable. When through fire or the normal process of

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9/ Study conducted by Dr. C. W. Waters. Unpublished manuscript.

harvesting the mature stand, forest conditions are necessarily disturbed and the soil exposed, every effort should be made to establish a complete new stand in the shortest time possible. Silvicultural measures favoring prompt and abundant regeneration are inimical to Ribes development. Disturbances to the soil cover resulting from intermediate cuttings, notably thinnings, should be held to a minimum. Crown thinnings are especially to be recommended in this respect, since forest conditions are disturbed as little as possible. Heavy low thinnings, particularly if followed by slash burning, create conditions favorable to Ribes establishment for a number of years. Broadcast burns, followed by prompt and successful planting and surrounded by Ribes-free territory should contain few Ribes. Partial disposal of defective and undesirable species following logging creates conditions very favorable to Ribes development; and unless reproduction is prompt and abundant, these conditions will persist for many years, necessitating extensive eradication work. This feature is an undoubted disadvantage to the method, and is a strong argument against its use in areas known to be favorable to Ribes where satisfactory establishment of natural reproduction is likely to be slow or doubtful.

Much remains to be learned about Ribes ecology. The principles outlined above are, however, well substantiated. Stand improvement and Ribes control are both of major importance on the best white pine sites and must be considered in relation to each other. Every effort should be made to employ to the fullest extent natural means available to assist in the elimination of Ribes from white pine stands.

EFFECT ON OTHER FOREST TREE DISEASES (9)

The effect of stand improvement on forest tree diseases other than white pine blister rust may be divided into two general classes, protection against disease and eradication of disease once established. Protection against disease is aided by stand improvement work through the removal of injured and poorly formed trees likely to become diseased and removal of tree species particularly subject to disease; creation of conditions favorable to rapid and vigorous tree growth which are unfavorable to disease; and, in conjunction with sound methods of cutting, harvesting mature trees before reaching an age when heart-rots and other diseases cause serious cull losses or before an appreciable crop of fungus fruit bodies are produced. Eradication is effected through stand improvement work by the burning of defective material, either by pile and burn methods or by the much more thorough broadcast burning which produces a maximum of pathological sanitation, and to a lesser extent through felling or girdling diseased trees which in many instances materially shortens the life of the disease organism.

The pathological consequence of stand improvement in immature stands is almost entirely protective. Stand improvement measures in immature stands, primarily directed to produce thrifty, vigorous, fast-growing and well-stocked timber stands composed of the most valuable species (which in the western white pine type are also the more resistant to disease), constitutes the most potent protection against forest tree diseases possible. In fact, the only effective remedy for forest diseases is protection.

Stand improvement in mature stands, primarily directed to remove defective and low-value trees and establish healthy and vigorous reproduction in their place, is equally desirable from a silvicultural and a pathological viewpoint. The effect of such measures is largely eradicative since disease is usually well established in the mature and overmature stands in which stand improvement is recommended.

In immature and mature stands, injury to residual trees by fire or mechanical means should be avoided as it is a well-established fact that such injuries materially favor the spread and development of many forest tree diseases - particularly heart-rot fungi.

It must be recognized that the relation of stand improvement to forest tree diseases is complex and that little specific information is available. There are undoubtedly important effects about which little or nothing is known. For this reason, it is impracticable to recommend stand improvement measures specifically directed to combat certain tree diseases; there are too many unknown factors. Available evidence does indicate, however, that best timber production, the central theme of stand improvement, is unfavorable to the spread and development of most forest tree diseases if general forest sanitation and hygiene are practiced.

EFFECT ON INSECT DAMAGE

Officials of the Bureau of Entomology and Plant Quarantine at Coeur d'Alene, Idaho, were consulted in an attempt to foresee the relation which the methods of stand improvement advocated in this manual may bear to subsequent insect damage. They state that the potential danger of extensive stand-improvement work lies in the possibility of the abnormal quantity of slash that is created acting as a favorable breeding place for bark beetles, which upon emergence may attack standing trees if an additional supply of such material is not available. Though there are a number of secondary bark beetles which will attack slash originating from such stand-improvement cuttings in young white pine stands, none of them are considered as being primary, nor are there any

records of serious damage resulting from their attack of healthy white pine. It is also true that those species found attacking larch, Douglas fir, etc., will seldom, if ever, attack white pine. Though such generalities are permissible, such intensive forestry has not been practiced sufficiently to permit the drawing of positive conclusions regarding its relationship to subsequent insect damage. However, it can be said that no such damage has been observed and none is anticipated, though there is always the possibility that the creation of an abnormal forest environment will produce unusual insect activity.

Improvement cuttings in mature white pine stands offer a more serious problem, as they carry some potential danger in relation to subsequent insect damage. As the bulk of the material cut in the improvement of mature stands is hemlock and white fir, with some Douglas fir, it can be quite definitely said that as the insects which attack such material are peculiar to these tree species; they will not attack white pine. However, in the improvement of such mature stands, if decadent and diseased white pine trees are felled, they become a source of potential danger to the residual white pine stand. Large pieces of white pine slash such as windfalls, cull logs, abandoned trees, etc., are readily attacked by the mountain pine beetle (Dendroctonus monticolae Hopk.), a primary insect which attacks healthy, mature trees. When such slash is created, it must be kept under surveillance, and if attacked by this insect, steps taken to eliminate the danger.

Insect behavior is peculiar in that it does not always follow established procedures, and it is very difficult, if not impossible, to consistently predict what will happen under given circumstances. Though available information would indicate that there is little to be feared from insect attack on account of stand improvement work, it must not be assumed that no further consideration need be given possible relationship. Areas in which stand-improvement work has been conducted should be closely watched for possible insect attacks. If standing trees are attacked, the situation should be promptly reported to the Forest Supervisor or directly to the Forest Insect Laboratory at Coeur d'Alene, Idaho, so that an examination may be made and steps taken to prevent further damage.

EFFECT ON WILDLIFE

Stand improvement measures described in this manual, if applied on an extensive scale, undoubtedly have an important effect on wildlife. Although present information is insufficient to recommend specifically measures to

encourage wildlife, careful consideration should be given to wildlife needs in areas where stand improvement is contemplated. In areas particularly important for wildlife production, stand improvement measures should be modified, or restricted if necessary, to properly integrate wildlife with timber production in accordance with land-use policies in effect.

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ALBUM OF
STAND IMPROVEMENT IN THE WESTERN WHITE PINE TYPE

Prepared by
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FOREWORD

The purpose of this album is to present in pictorial fashion timber stand improvement measures applied in the western white pine forests of northern Idaho giving the reader a visual grasp of stand conditions encountered, and how the various stand improvement measures have been actually applied on the ground. Stand improvement practice is in the process of development--application on an extensive scale began with the advent of the CCC--and none of the practices here illustrated are represented as being the last word. Many are frankly experiments. Stand improvement is, of course, closely linked to regeneration methods applied in the type. Clear-cutting, seed tree, and shelterwood methods all have been and are being applied in the western white pine forests, and to a large extent the need for stand improvement arises in the effective carrying out of these regeneration measures. More experience, backed up by sound research, is necessary before stand improvement practice in the white pine forests can be considered definitely established.

Before a program of stand improvement can be fairly appraised, certain silvicultural and economic facts must be recognized.

Consider first the nature of the forest. The western white pine forests are normally even-aged and usually of great density. Silviculturally they are a complex and highly variable association of several species differing widely in their silvical requirements. Principal associates are western white pine, western larch, Douglas fir, lowland white fir, western red cedar, and western hemlock. Minor associates are Engelmann spruce, alpine fir, and lodgepole pine. Individual timber stands may vary from almost pure white pine to pine in every conceivable combination with its associates. Management methods must be almost as diverse as the stands in which they are applied. Almost every stand must be individually considered; standardization of methods is possible in only a general way.

Second, some difficult and stubborn management problems must be faced.

The western white pine forests are fire forests. In its natural state, the white pine type was largely perpetuated by fire. The fire control problem is one of the most difficult in the United States. Fire colors every phase of management practice; methods of cutting, stand improvement, slash disposal, and the like, all have a direct bearing on fire control and frequently must be modified to avoid undue conflict with fire control requirements. At the same time, applied intelligently and with discretion, fire is a powerful and useful management tool. It is the only practicable means of physically disposing of large volumes of defective and inflammable materials which so often accumulate. It also has important physical and chemical effects on the soil--at present imperfectly understood--which may be beneficial or detrimental, depending upon particular circumstances. Fire also seems to have some important sanitary effects.

The widely differential value of the associated species is another stubborn problem. Briefly, only western white pine and western red cedar as poles are of sufficient value to log extensively under existing market conditions. Of these species, western white pine is of outstanding importance; lumbering in the white pine region is built around the valuable white pine. Cedar for transmission poles, though of equal if not greater value on a unit basis, occurs much less abundantly and, consequently, is of less total importance. The selling value of other species is usually insufficient to meet the cost of production, even if nothing were allowed for stumpage, and as a consequence these species are logged much less extensively. The disposal of large volumes of unmerchantable timber, often necessary to consummate silviculturally desirable methods, is a major management problem that can be effectively solved only by better markets.

Finally, the white pine forests have their full share of natural enemies. The very existence of western white pine as a commercially important species is threatened by the white pine blister rust. Insects, particularly the mountain pine beetle on white pine, exact an important annual toll. Susceptibility of western hemlock and lowland white fir to wood rotting fungi is an important contributing reason why these species are of low value. In order to realize on the heavy investments necessary to protect the western white pine forests from their natural enemies, it is important that they be maintained at full productivity. This is where stand improvement, directed to making forest lands more productive, comes in.

KENNETH P. DAVIS,
Associate Silviculturist.

Missoula, Montana,
February 28, 1938.

CLEANINGS AND THINNINGS IN IMMATURE STANDS

Cleanings are made in young stands, averaging less than about two inches in diameter, to improve the composition and distribution of the reproduction stand by removing undesirable trees that are competing or likely to compete with trees of desirable species and form. Experience and observation indicate that an increase in the proportion and quality of the most valuable species can be most effectively and cheaply accomplished while the stand is very young. As the stand grows older expense of treatment rapidly increases and at the same time less can be done to improve composition. To be most effective, cleanings should be repeated one or more times. Cleanings are accomplished with powerful "nippers" that can cut trees up to two inches in diameter without difficulty. Hatchets and knives are also sometimes used. Larger trees can be best cut with an ordinary ax. Cleaning operations are relatively quick and inexpensive, requiring from one to five man days per acre. Slash disposal is seldom necessary.

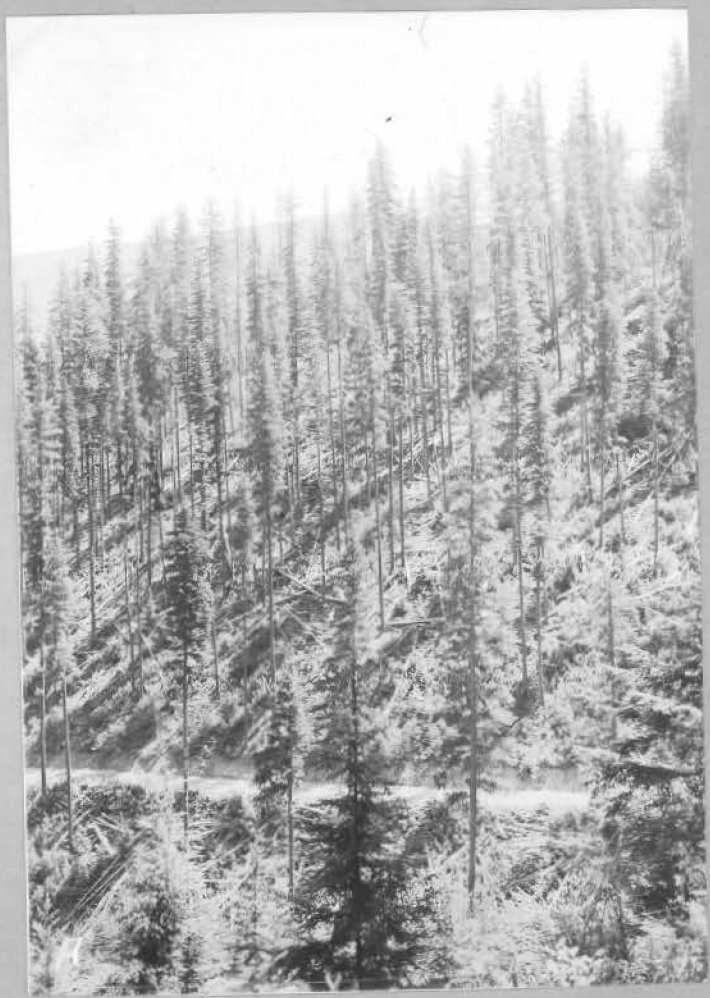
Thinnings, or perhaps more accurately improvement cuttings, are essentially similar to cleanings but are applied to older stands. The primary purpose is to release trees of desirable species and form from competition by undesirable trees to increase the proportion and quality of the most valuable trees at maturity. A secondary purpose is to increase the rate of growth. Thinning the normally dense reproduction stands in the white pine region has been found to be a rather expensive job. To keep costs commensurate with anticipated results, it is necessary to "cut corners" to get maximum results at minimum cost rather than attempt intensive work. Thinnings applied are of two general classes; thinnings from below where all but trees of value for future growth are cut, and thinnings from above or crown thinnings wherein only trees competing or likely to compete with trees selected as possibilities for future crop trees. Although not resulting in a particularly pretty looking job, crown thinnings require less cutting and are consequently less expensive, create less slash and concomitant fire hazard, and do not run the risk of opening the stand up too much at one time.

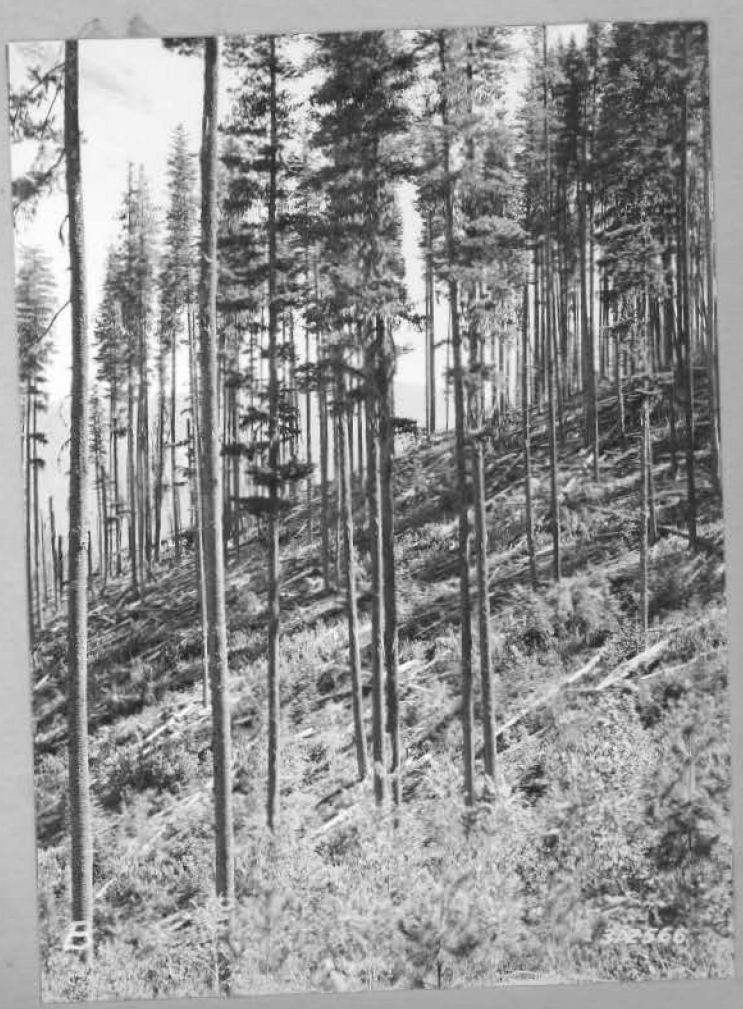
Typical terrain in the western white pine forests. Looking up Steamboat Creek into one of the largest bodies of virgin white pine timber left in Idaho. Coeur d'Alene National Forest.

A cleaning operation in an early Forest Service seed tree cutting in Sands Creek, Deception Creek Experimental Forest. Although the area reproduced abundantly and with a satisfactory number of western white pine, the reproduction stand was largely dominated by western hemlock and lowland white fir. This was corrected by a cleaning operation.

A. Seed tree stand 18 years after cutting. The seed trees have ~~since~~ been removed since this view was taken

B. and C. Near views of reproduction under seed trees after cleaning. Note that white pine occupies a dominant position. The cleaning took 3 to 5 CCC man days per acre.

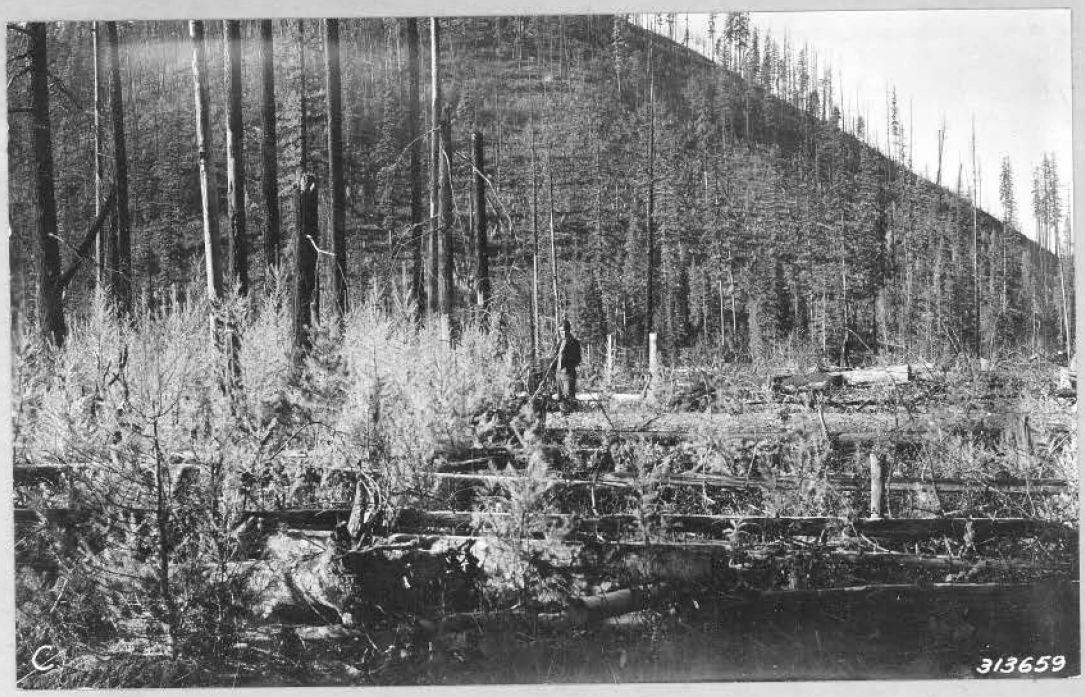




A. Untreated stand dominated by western larch.

B. After treatment; white pine released.

Dense natural reproduction following a severe forest fire in 1926 near old Dalkena Camp 1, Kaniksu National Forest, dominated by western larch. Among the larch, however, there was a good sprinkling of white pine which was given release cleaning. Views A and B give a good idea of the stand before and after treatment.



C. Juncture of thinned and unthinned plot.

Some of the white pine buried under the larch, as shown in D, will in time make its way up into the dominant stand. Some will not. The cleaning was done largely as an experiment to see what would happen. View C shows the sharp contrast between a treated and untreated sample plot.

Area clear-cut of white pine in 1914-15, while in private ownership, leaving a rather dense residual stand of defective hemlock and white fir. Despite the dense overwood, abundant natural reproduction came in over most of the area as shown in A. Although white pine was well represented it was badly overtopped and suppressed by the more tolerant hemlock and white fir.

In treatment, hemlock and white fir up to 20 inches d.b.h. was felled and the slash burned. Larger trees were girdled. White pine in the reproduction stand was given release by a cleaning. Response to release was prompt and marked. Within two years after treatment the rather spindly white pine had quite noticeably begun to fill out and accelerate in growth.

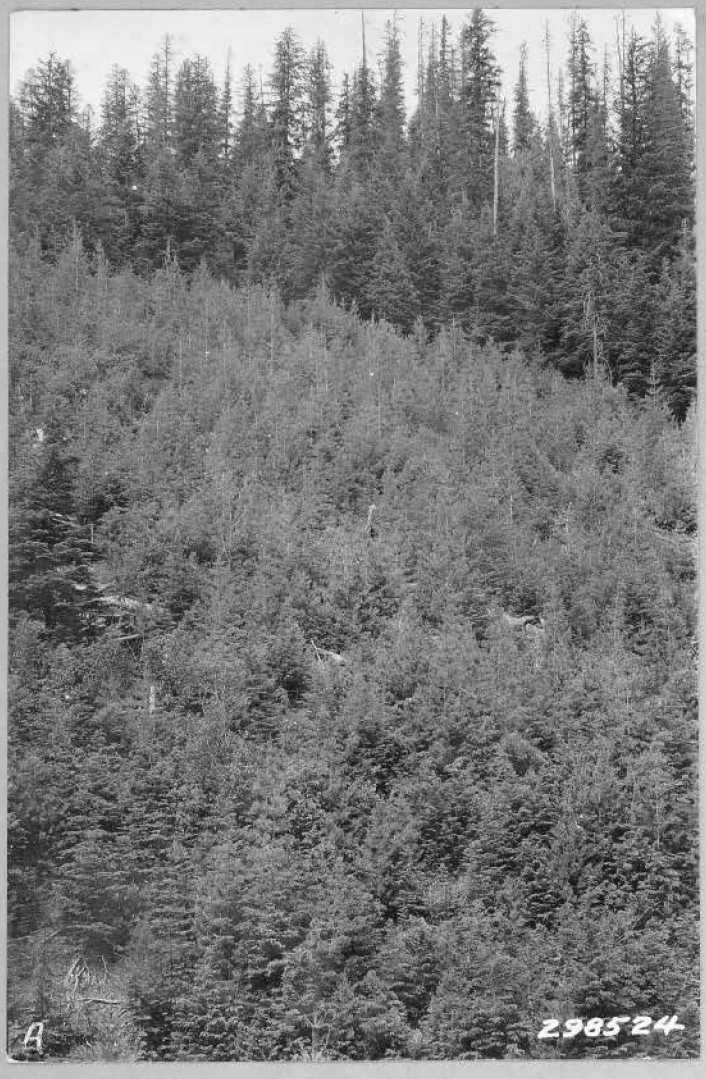
Sands Creek, Deception Creek Experimental Forest.

358298

B. and C. After treatment. Larger trees were girdled and white pine reproduction released from competing hemlock and white fir.

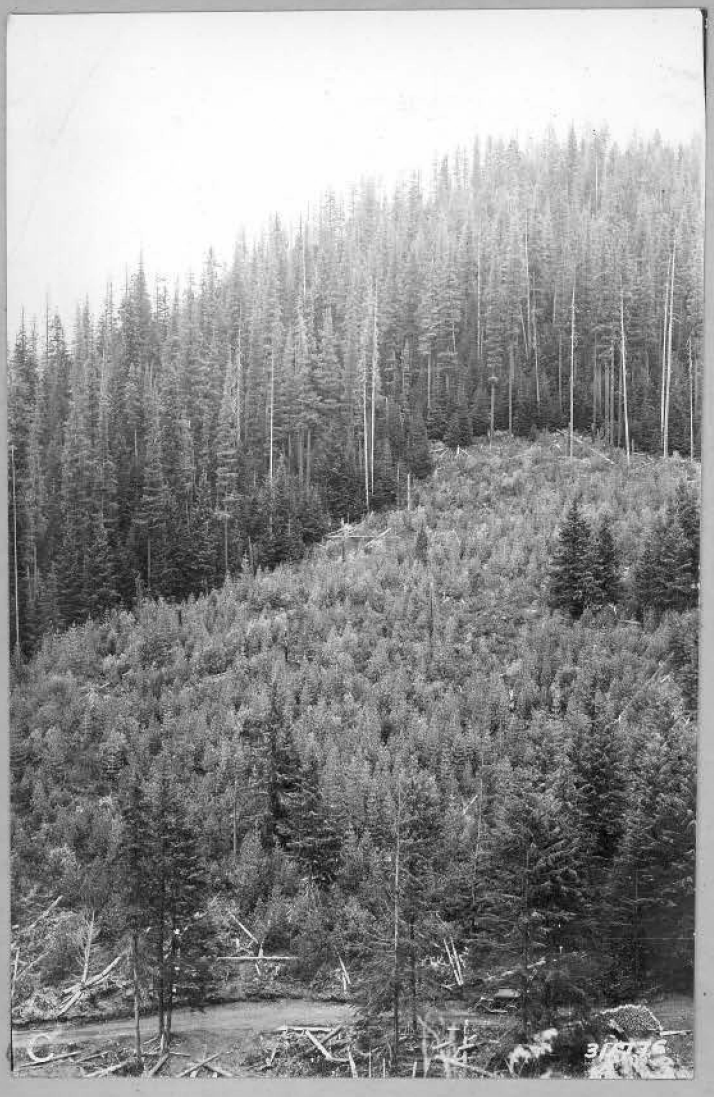
D. and E. Dense reproduction before treatment.

F. Two years after treatment. Released white pine trees already thickening their crowns and putting on accelerated growth.



Thinning in a 20-year-old stand of white pine, white fir, and hemlock resulting from a strip-cutting experiment made on the Coeur d'Alene National Forest in 1910. Deception Creek. Thinning made to favor white pine.

A. and B. Before and after thinning.



C. and D. above. General views of one of the clear-cut strips. In this strip the reproduction was nearly pure pine, was well spaced, and needed no treatment.

The area surrounding was left uncut, as shown in C. In a little over 20 years the formerly suppressed and spindly hemlock understory along the margins of the cutting have thickened their crowns and closed over the ground. No new reproduction could develop. In D. this understory has been removed for a short distance back from the edge of the old cutting.

E. Near view of thrifty white pine in clear-cut strip.

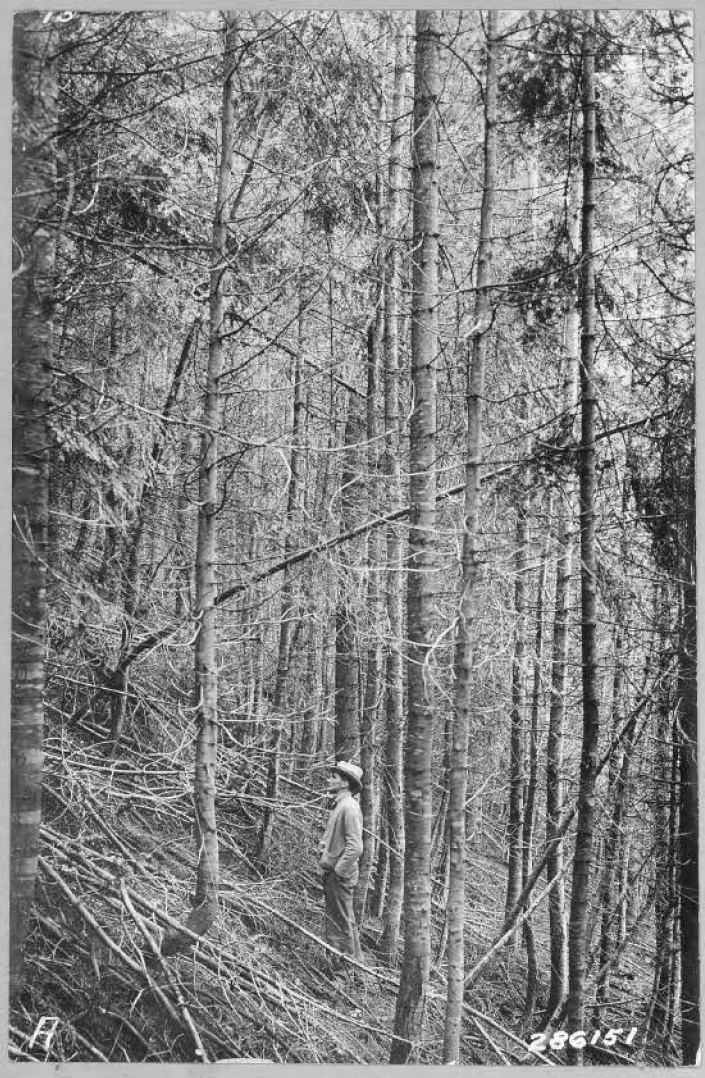
A. General view of thinning operation in 20-25 year old white pine, western larch, and white fir stand on Big Creek, Coeur d'Alene National Forest. The stand was a little over half white pine in number but was severely overtopped by the larch.

B. Contrast between thinned and unthinned areas. The boundary angles off to the right from the car.

C. Near view of the excellent white pine reproduction. Rate of growth, however, was temporarily slowed up following thinning due to the shock of sudden release. The thinning was done in 1934, and in 1935 the leader growth in the thinned stand was a little less than half of that in the unthinned stand. The retardation in growth was also noticeable in 1936 and 1937. In a few more years the white pine will become adjusted to the more open conditions.

D. Western white pine reproduction barely visible under the overtopping larch. Some of the pine will make its way up into the dominant stand in the course of the next 20 years or so. Much will not, however, and the proportion of white pine in the final stand will be materially lessened as a consequence.

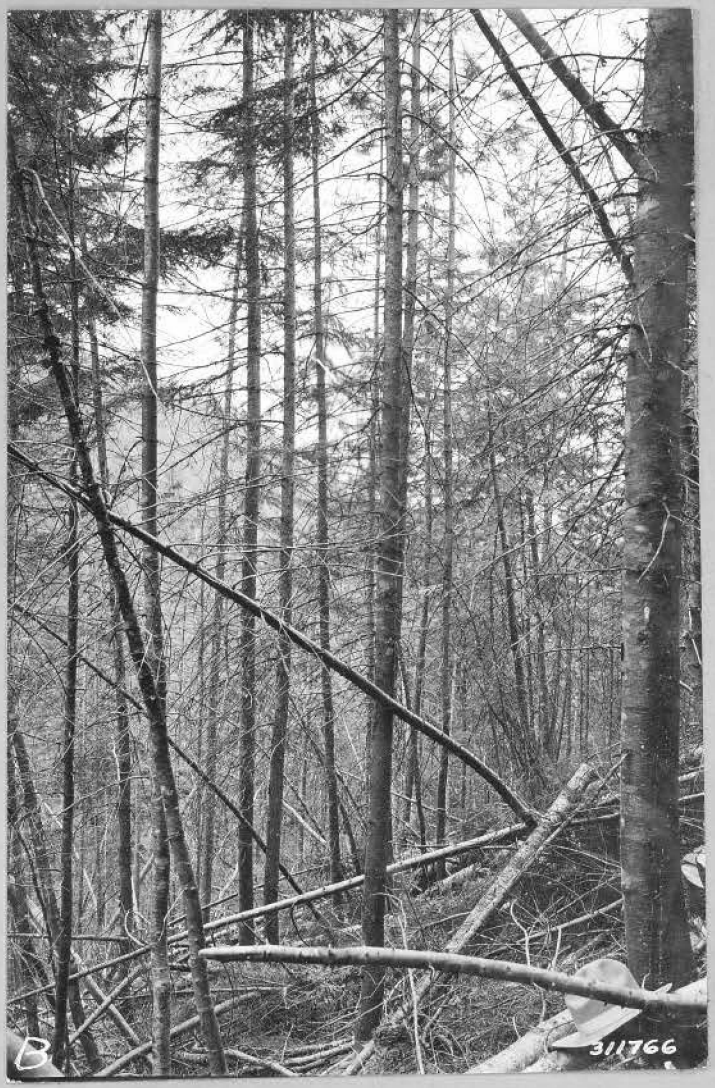
E. Another general view of the stand left after thinning. As is evident, the remaining stand is almost pure white pine. Whether or not it would have been better to have retained some larch and white fir in admixture remains to be seen.



A. Before thinning.

B. After thinning.

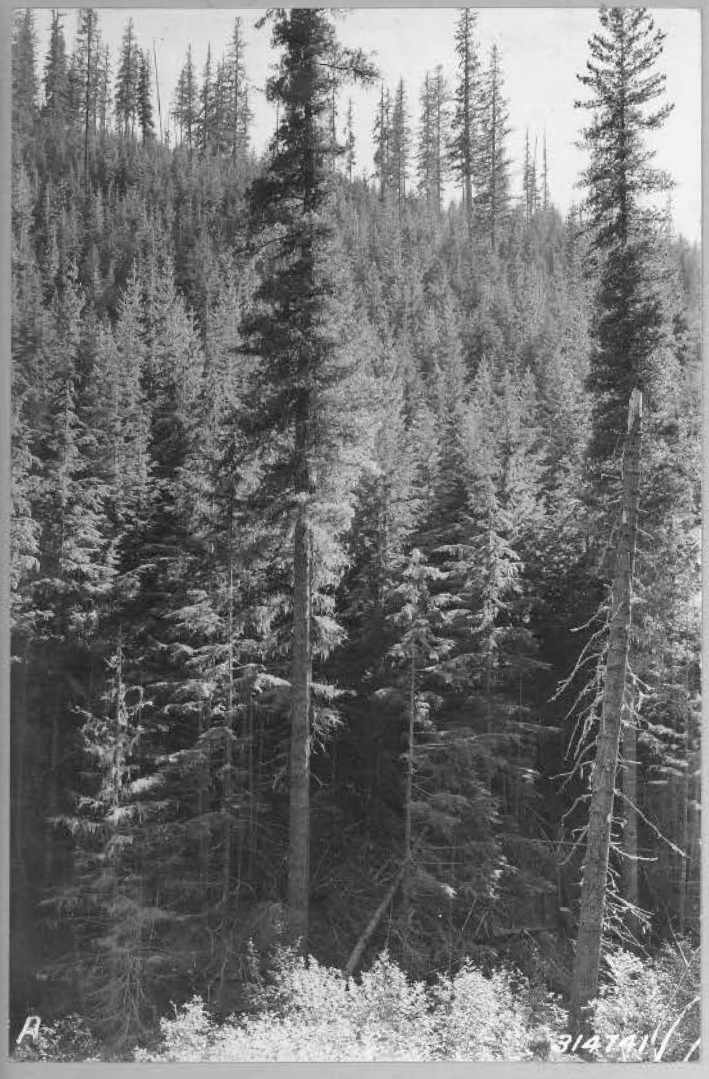
A. and B. Thinning from below in a 65-year-old stand principally composed of western white pine, white fir, and Douglas fir. The stand was thinned to leave about 150 square feet of basal area per acre from an original density of about 280 square feet. Although the residual stand looks very attractive, it is doubtful if the actual results will be commensurate with the costs, which were high. Deception Creek Experimental Forest.



B. After thinning.

A. Before thinning.

A. and B. Thinning from above, or crown thinning, in a 55-year-old stand of white pine, hemlock, and white fir. Although white pine is well distributed throughout the stand much of it was in an intermediate position in the stand with hemlock and white fir dominant. By the thinning, the better white pine trees were selected and sufficient cutting done to release them from at least their immediate competitors. Trees not actually interfering with these selected trees were not cut. Slash was lopped and placed as close to the ground as possible. Deception Creek Experimental Forest.



A. General view of area in which crown thinning was made.

B. Remains of an old alder clump. These relics scattered through the reproduction stand indicate that at one time the area must have supported much deciduous brush through which the coniferous reproduction finally made its way and gained ascendancy.

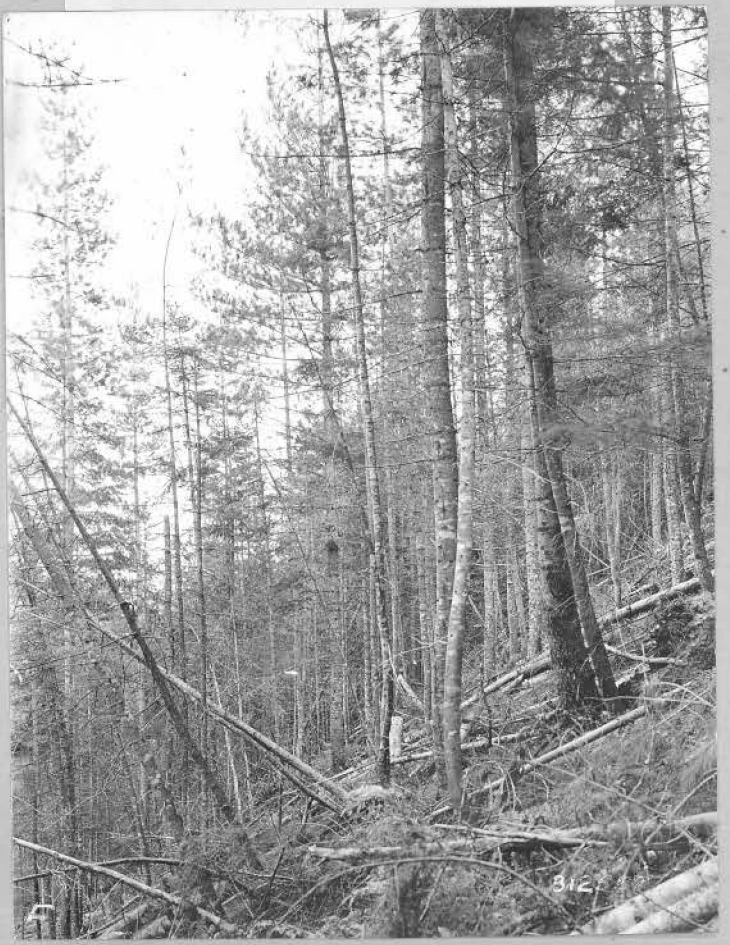
C. Brush piled for burning in fire lanes. To permit quick access to all parts of the area and to give a line to work from in case of fire, strips about 20 feet wide were cleared gridironing the area at intervals of about 400 feet. All slash piled and burned in these strips.

D. Before thinning.

E. After thinning.

D. and E. Another before-and-after set. Note the great density of the stand before thinning.

F. General view of thinned area. The fire hazard has been definitely increased for at least 10 years. Cost of slash disposal is prohibitive in this area. Crown thinnings leave a messy looking area but they are silviculturally effective and are less expensive than any other kind of thinning.



Thinning to favor western white pine in an extremely dense 40- to 50-year-old stand near Luby Bay, Kaniksu National Forest. Before thinning the stems were, literally, as thick as hair on a dog's back. Such stands are a typical result of single burns on the better sites and often stagnate in growth for many years.

Note the large amount of down timber in the lower picture. This is an almost sure indication of a single burn; this material would be consumed if the area is burned over a second time.

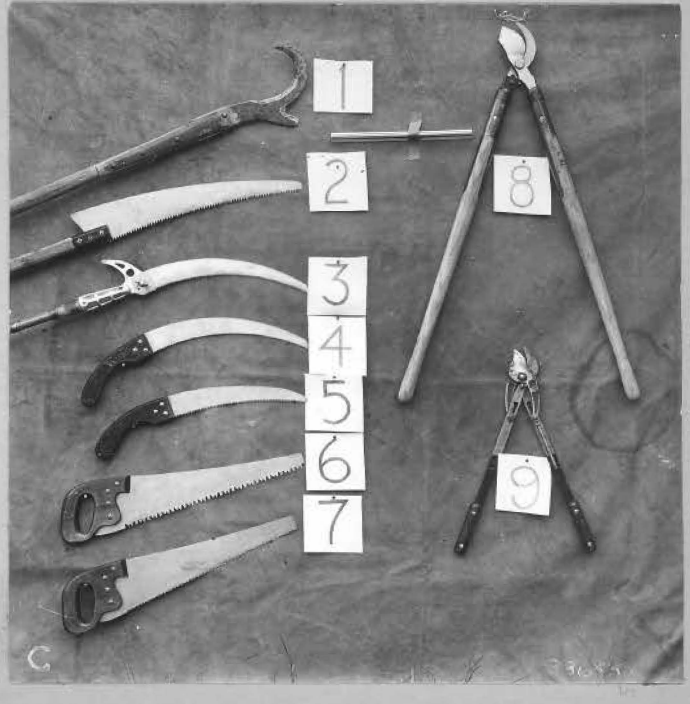
PRUNING

The sole purpose of forest pruning is to increase the value of the final product. This is accomplished by artificially removing dead limbs, and live limbs not essential to the tree, from the lower portion of the bole to produce a higher proportion of knot-free wood in the tree at maturity. Practical difficulties of high pruning limit pruning to the first 16-foot log in the tree. In western white pine stands 100 to 120 years of age (the merchantable age of the future) the first 16-foot log contains from 25 to 35 percent of the total volume of the tree. Stands of this age will produce very little, if any, clear lumber without pruning. To be most effective, pruning should be done while the tree is small, about 4 to 6 inches d.b.h., so that the size of the central knotty core is held to a minimum.

A. Before pruning.

B. After pruning.

A. and B. Pruning with a pole saw in 40-year-old western white pine, Deception Creek Experimental Forest. These trees are of just about the right size and kind to prune to best advantage. A full 16-foot log can be cleared in one operation without removing more than about 20% of the live crown, yet the diameter of the tree is small keeping the size of the central knotty core to a minimum. At the same time the limbs are small, easily cut, and the scars are not liable to become infected or cause pitch pockets in the wood.



C. Tools tested for pruning. The pruning saw is by far the best all-around tool for forest pruning. It is inexpensive, durable, and efficient.

For pruning above arm's reach, tool no. 2, a pole saw, is very satisfactory. For hand work, no. 5 is about the best of the group. Nippers, like tools 8 and 9, are limited in their application, more expensive, and do poorer work on the average than the saws.

A. Before pruning.

B. After pruning.

A. and B. Pruning in a fast growing 50-year-old stand in Searchlight Creek, Coeur d'Alene National Forest. While the trees in this stand have passed their best pruning size, they are growing rapidly and will put on much clear growth at a maturity age of about 120 years. Without pruning, little if any clear lumber would be produced at this age as the stand is open and the limbs large and very persistent.

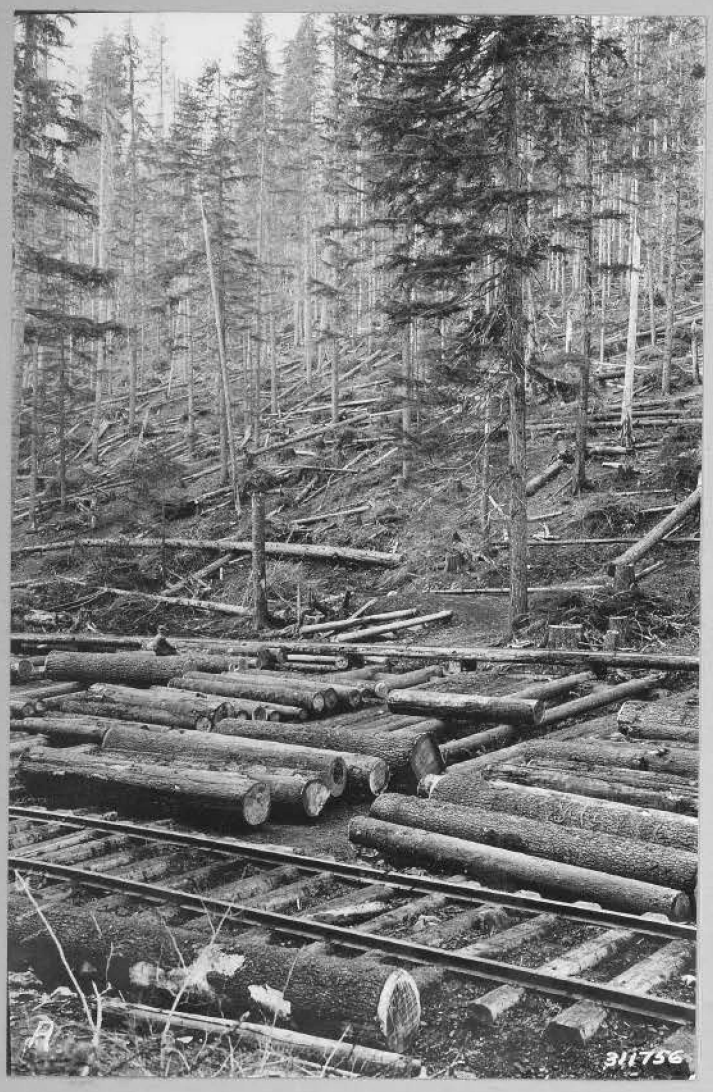
A. Scars left after cutting small limbs like these heal over rapidly and are not liable to become infected or cause pitch pockets or other blemishes in the wood.

B. A group of pruned trees in Searchlight Creek, Coeur d'Alene National Forest.

STAND IMPROVEMENT IN MATURE STANDS

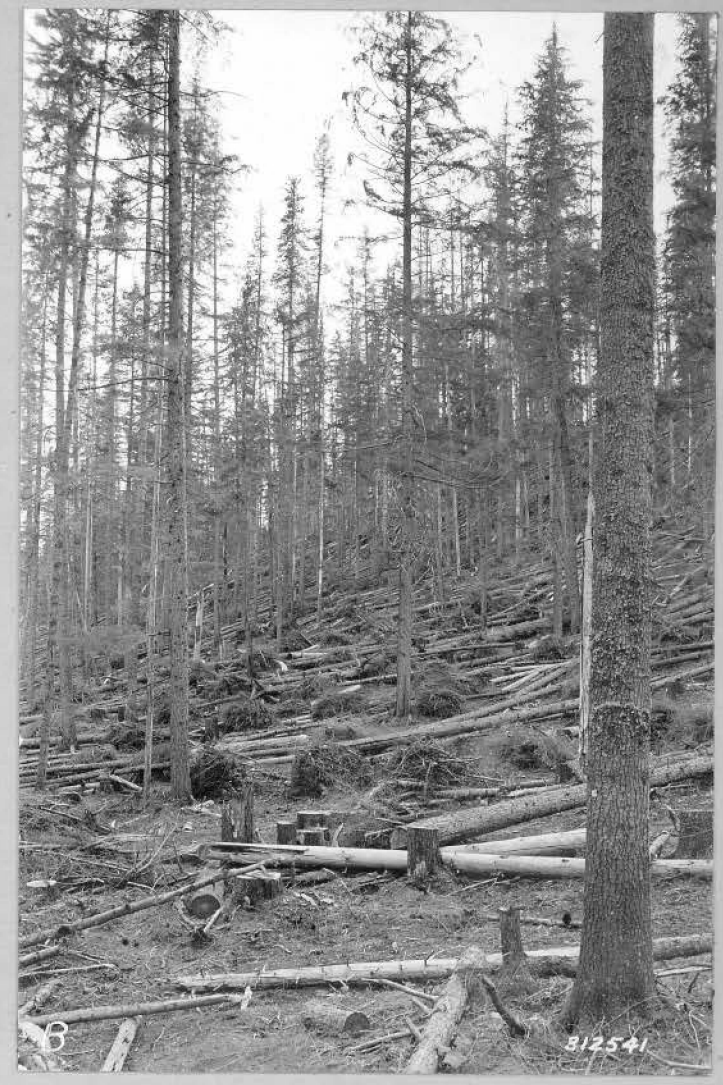
Stand improvement in mature stands is primarily concerned with the disposal of defective and unmerchantable species to permit the establishment and proper development of desirable reproduction. It is an integral part of the method of cutting, essentially a supplement to the logging of merchantable timber. It is largely necessitated by the fact that a large proportion of the existing merchantable stands in the type contain much defective timber of no possible value, or sound timber of species having but slight value under existing markets. It is hoped and expected that much of the need for this class of work is transitory; that as existing timber stands in poor silvicultural shape are cut over and put in productive condition, as cultural measures are regularly applied in immature timber to prevent the development of low-value stands, and as improved market conditions permit better utilization of all species, the need for extensive improvement work in mature stands will be largely avoided. Although no one likes to sacrifice wood of any species (wood that took many years to grow), a square facing of silvicultural and economic facts indicates that for the present, at least, foresters are faced with a difficult and expensive but necessary job of making productive areas that are now occupied by defective and low-value mature stands.

Stand improvement in mature stands falls into two general classes, partial disposal and complete disposal. In partial disposal enough of the most defective and least merchantable trees are removed, usually by pile and burn methods, to open up the stand sufficiently to permit the establishment of natural reproduction. The better trees are reserved for a future cut. Complete disposal is necessary when the stand is so heavily defective that there is nothing worth saving for a future cut. By this method all merchantable trees are removed and those remaining slashed and broadcast burned. Planting usually follows burning.



Disposal, by pile and burn methods, of defective and unmerchantable western hemlock and lowland white fir left after logging, (A) Tom Lavin, and (B) Hudlow Creeks, Coeur d'Alene National Forest.

In these stands only western white pine and some Engelmann spruce were merchantable. The removal of these species did not open up the stand sufficiently to permit the satisfactory establishment and development of natural reproduction. Much of the fairly dense cover of hemlock and white fir remaining (largely defective and in the form of an understory) had to be removed to make the white pine seed trees reserved at the time of logging effective in producing natural reproduction. In the conduct of the work from 10 to 30 trees per acre were left to give the reproduction some protection, especially on exposed situations, and to reserve the better trees of all species for a future cut. This kind of work costs from $25 to $35 per acre.

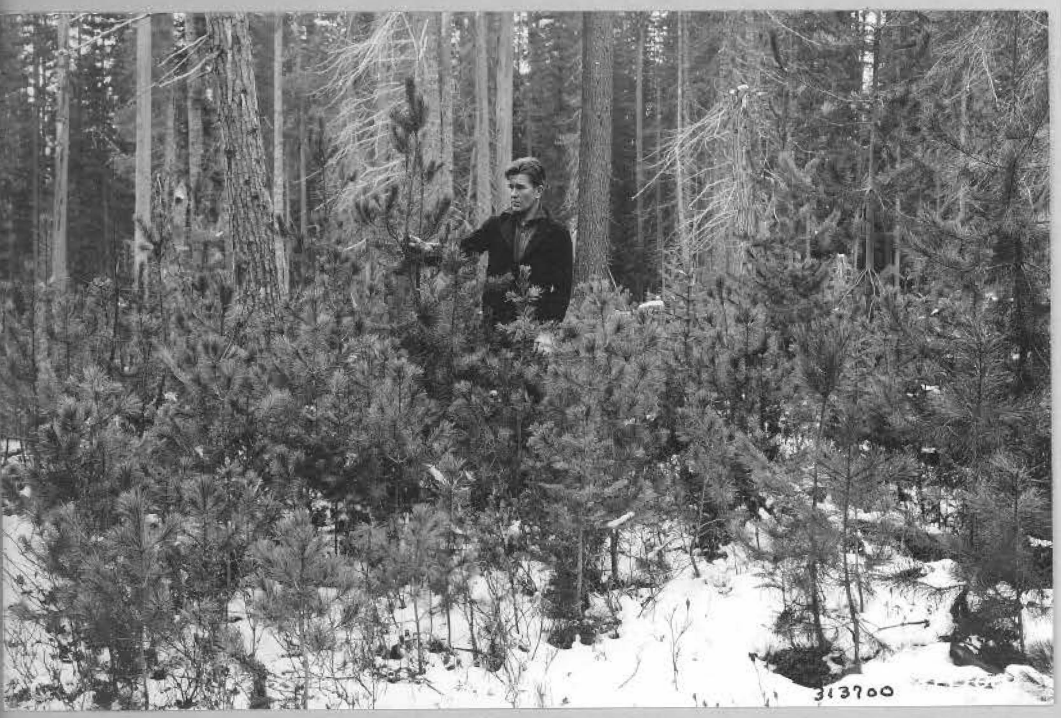


A. Disposal of dead, defective, and unmerchantable trees following logging in upper Hudlow Creek, Coeur d'Alene National Forest. Much of the plentiful down timber in this picture was dead at time of logging and was felled to decrease the fire hazard.

B. Slash piled for burning in Tom Lavin Creek. Note western white pine seed tree in right foreground.

C. Material left on the ground following logging and subsequent stand improvement in Hudlow Creek. None of this timber, unfortunately, had any present or prospective sale value.

A., B., and C. Stand after logging and subsequent removal of an understory of western hemlock, Barney Creek, Coeur d'Alene National Forest.

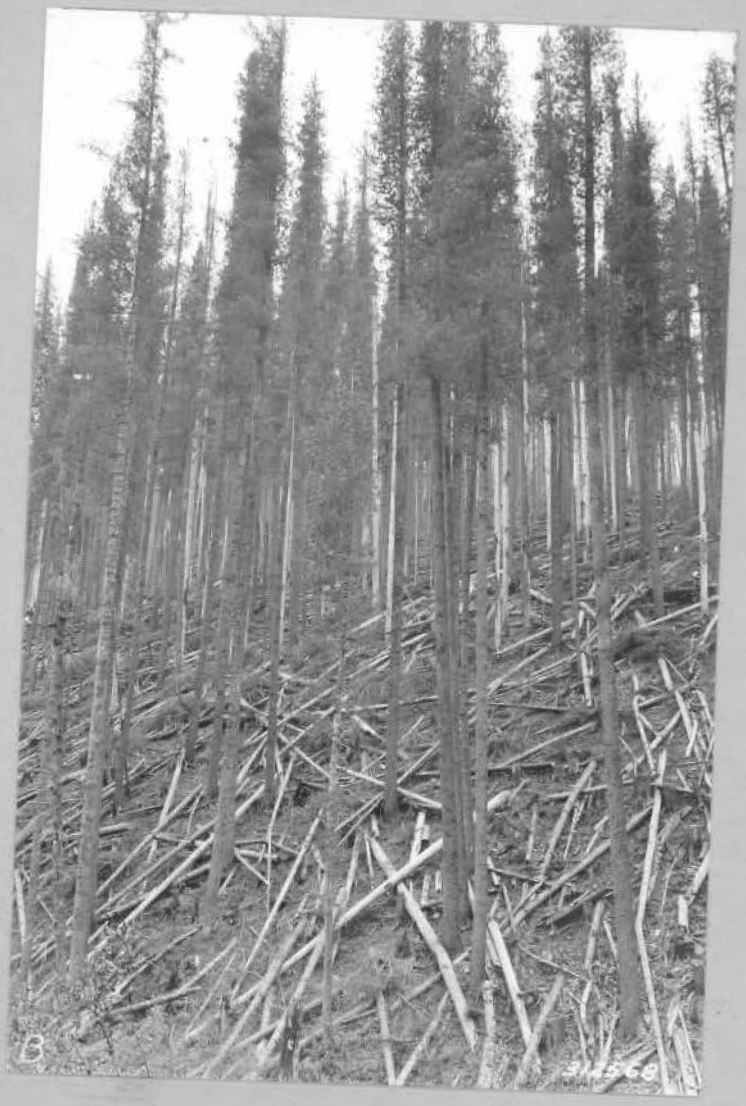


The reason why it is necessary to remove a good share of the residual stand, particularly the hemlock understory, to get satisfactory natural regeneration. The reproduction in all three pictures is 10 to 12 years old and growing on the same flat. Upper West Branch, Kaniksu National Forest.

A. Spindly, weak reproduction making very poor growth under residual stand in which no hemlock disposal was done subsequent to logging.

B. Fairly good reproduction under a residual stand partially opened up.

C. Thrifty and vigorous natural reproduction under an open shelterwood.



A. and B. Disposal of defective and unmerchantable trees before commercial logging is an alternative being experimentally tested to the usual practice of disposal after logging. By this procedure, shelterwood conditions are created in advance of logging. When reproduction is established the remaining shelterwood, entirely composed of merchantable timber, is clear-cut. Though somewhat limited in its application, the method has some possibilities.

Views A. and B. were taken on a north slope in the Deception Creek Experimental Forest.

A. and B. More pre-logging disposal. Hannah Creek, Kaniksu National Forest. The residual stand will be logged as soon as a reproduction stand is well established. The hemlock cut in the stand improvement operation was almost entirely defective.

A. Before treatment.

B. After treatment.

A. and B. Pre-logging disposal of hemlock, white fir, and lodgepole pine near the High Bridge, Kaniksu National Forest. In this area considerable quantities of sound timber, unmerchantable at the time, were cut in close proximity to a main transportation route making the operation of doubtful economic wisdom.

Another variety of pre-logging disposal. Experimental girdling of understory hemlock, Deception Creek Experimental Forest.

A. Stand before treatment. Note the fairly well spaced western white pine interspersed with the smaller hemlock which form an understory.

B. and C. After girdling.

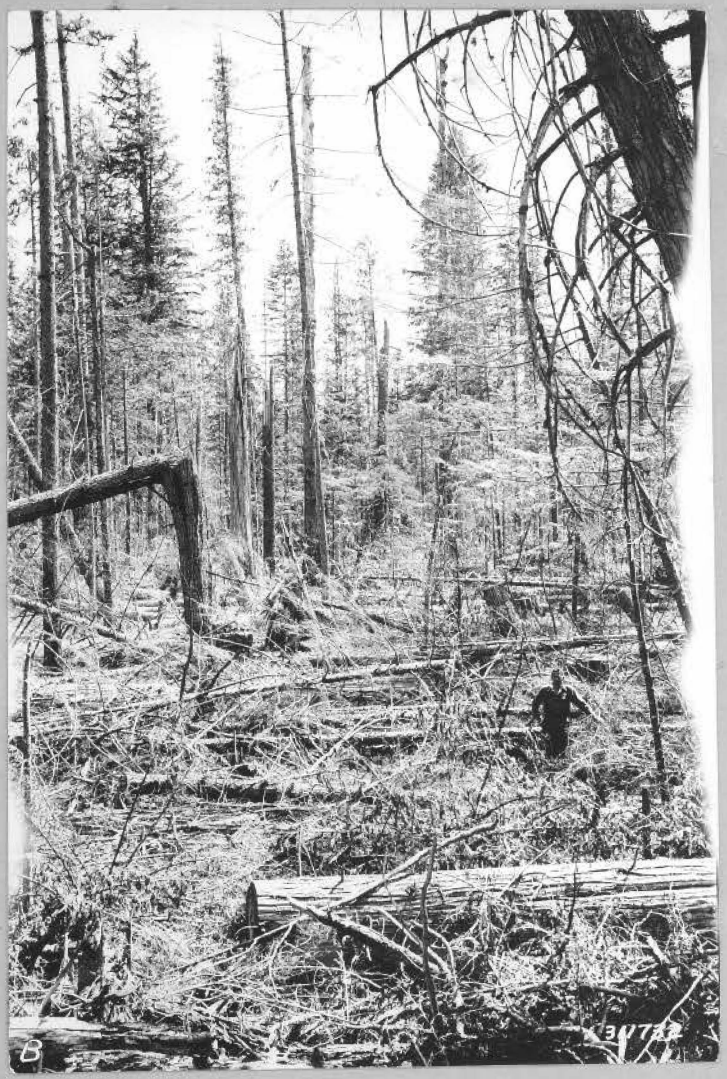
Max diam 30" +
Age 160-180
Hgt max 175'+

Cutting in alternate clear-cut and shelterwood strips, Ames Creek, Deception Creek Experimental Forest. The dominant stand in this area was almost pure western white pine. The pine was clear-cut in alternate strips including about 60 percent of the total area, and the residual hemlock understory slashed and broadcast burned. On the remaining strips, which were located as advantageously as possible for seed dissemination, shelterwood conditions were created by logging about 50 percent of the white pine and felling the hemlock understory. As soon as natural reproduction is established over the entire area the shelterwood will be clear-cut.

A. and B. Views in the Ames Creek strip-shelterwood cutting, Deception Creek Experimental Forest.

A tough silvicultural and economic problem. Dense, over-mature, defective, and entirely worthless hemlock and white fir. Though green, such areas are entirely non-productive and will remain so for an indefinite period. At the same time, such stands often occupy the best timber growing sites.

Restoration of such areas to productivity requires strong-arm methods. About the only practicable thing to do is to log out all merchantable timber, slash the remainder and broadcast burn. Planting is necessary on large areas.



After-logging ruins of a veteran 300- to 400-year-old stand on private land near the Four Corners, Kaniksu National Forest.

The utter futility of trying to clean up this awful mess by hand piling and burning of the slash is obvious. Even if enough of the slash could be disposed of to make the area reasonably safe from a fire control standpoint, the residual stand (almost entirely defective and worthless) is dense enough to prevent the satisfactory establishment of natural reproduction. Broadcast slashing and burning is the only alterna tive.

C. Same general stand as shown in A. and B. Attempting to pile and burn slash in such stands is just a waste of money.

D. The all-too-frequent aftermath of partial cutting in heavy, over-mature stands. A fire sweeps through the area after logging leaving a maze of highly inflammable snags that will almost surely pave the way for a second and even more destructive fire. Although fairly good natural reproduction in such areas often becomes established after the first fire, none will survive and little additional will become established after the second fire. Picture taken near old Humbird Camp 19 on Kaniksu National Forest.

A. Dense stand of hemlock and white fir left after logging out merchantable white pine.

B. Residual stand clear-cut.

The only practicable method of restoring to productivity areas supporting large volumes of defective and unmerchantable timber is to clear-cut, broadcast burn, and usually plant. Admittedly a drastic and rather ugly method, it is none the less effective. If such areas are to be treated at all, broadcast burning is the only alternative. Views taken in Sands Creek, Deception Creek Experimental Forest.

C. Broadcast burning.

D. After burning. Area thoroughly cleaned up and ready to plant.

E. Fire lane clearing along the edge of an area to be broadcast burned.

After felling, before burning.

After burning.

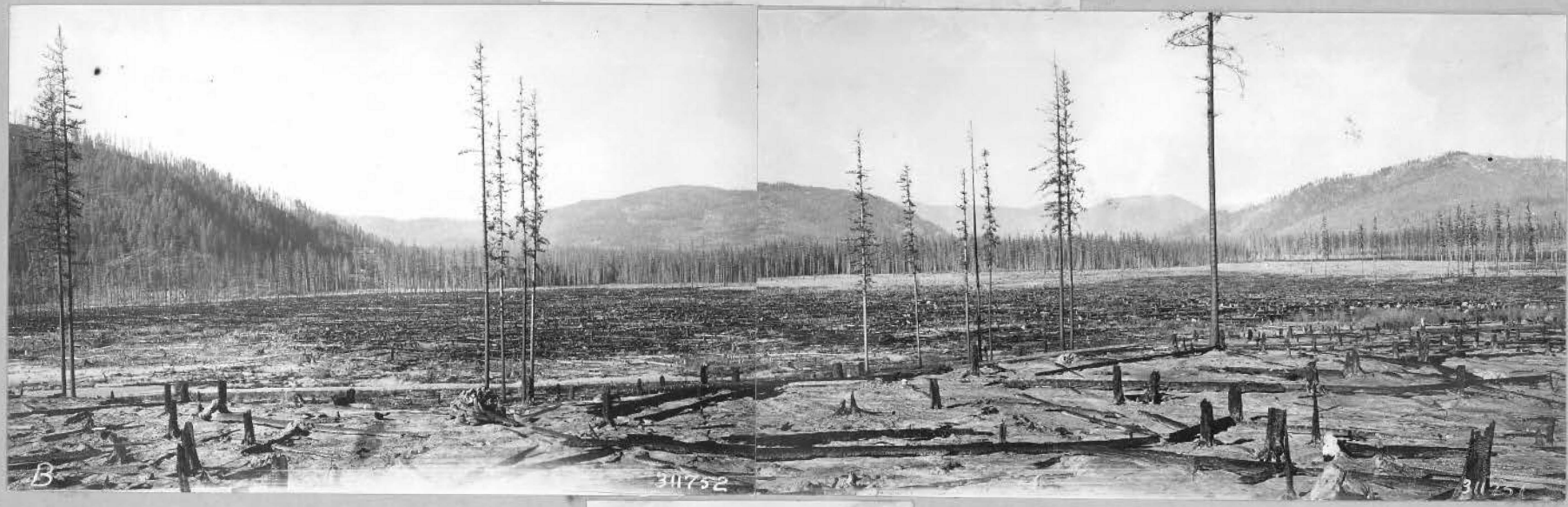
Barry C.

After felling, before burning.

After burning.

A. B. C. and D. Broadcast burning in Barney Creek, Coeur d'Alene National Forest. These areas were planted following burning. Although such areas are in general good planting chances, it is sometimes better to delay planting for a year or two following burning to let the dense mat of roots in the soil decompose a little. The attempt to save a few white pine seed trees along a hogback ridge, as shown in C, by clearing slash away from around them, was not successful. The trees were all fire-killed.

After felling, before burning



After burning

A. and B. Extensive clear-cutting and broadcast burning near Kalispell Bay, on Priest Lake, Kaniksu National Forest. Area logged in 1924 and accidentally burned over in 1926. The area has been planted with ponderosa pine which is making fine growth.

A. After felling, before burning.

B. After burning.

A. and B. A large broadcast burning project near the old Boswell Ranger Station, Kaniksu National Forest. The standing trees are veteran western larch. These trees are astonishingly fire resistant and unless the slash is heavy and close around their bases, many of them will survive. In general, however, it is impracticable to attempt to save live trees in broadcast burning.

A. and B. More broadcast burning. Along Pelke road, Kaniksu National Forest. Few of the standing larch trees hown survived the hot fire resulting from the heavy slash.

C. Extremely hard burn on Kalispell Bay broadcast burn. In this area all timber was fire-killed before being felled for the broadcast burn cleanup job. As a result, fuels were well dried out and were almost entirely consumed--the usual happening in second burns. This area has been pretty severely treated and net effect on the site remains to be seen.

A. and B. Before and after broadcast burning near old Boswell Ranger Station, Kaniksu National Forest.

A. Rotten 20-year-old hemlock snags with dense natural reproduction beneath.

B. Same as A. after felling the snags to reduce the fire hazard.

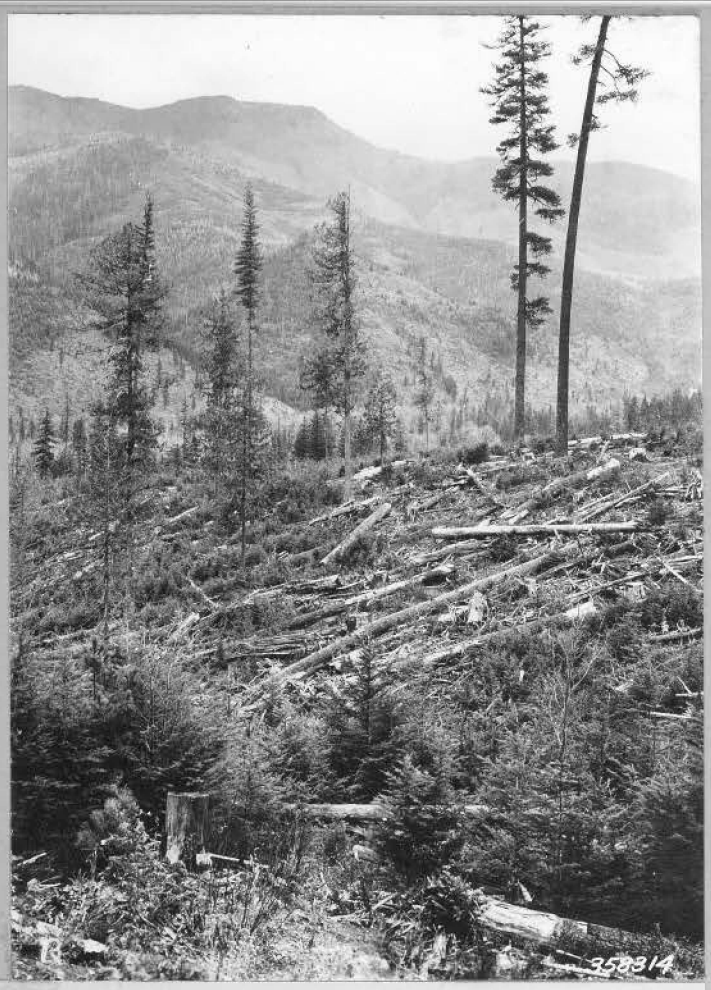
Disposal of defective and unmerchantable trees by girdling has been employed as an alternate method to broadcast burning. Views A. to E. were taken near Rock City, Coeur d'Alene National Forest.

The area was logged in about 1915, taking out only western white pine which made up about 25 percent of the total stand. The dense stand of defective hemlock remaining was killed by girdling.

The principal objection to girdling is the high fire hazard offered by the dead snags. Once started, fires are almost impossible to control in such stands. Girdling is much cheaper than clear-cutting and broadcast burning and the results fairly satisfactory silviculturally.

C. Clearing a fire lane around the girdled area.

D. and E. Natural reproduction in the girdled area after snags have been felled. In general, natural reproduction was abundant and included a good distribution of white pine. Much of the reproduction stand was dominated by hemlock, however. In the views shown, a partial cleaning has been done removing the larger hemlock and leaving a very satisfactory reproduction stand. As shown, the reprcduction has already closed over felled snags.



Before and after snag felling on the Rock City girdling area, Coeur d'Alene National Forest. The fire hazard is greatly reduced by getting the snags down on the ground. Note the few white pine seed trees still standing that were reserved at the time of logging.